

ABSTRACT

SPAKE, JESSICA RENE STURDEVANT. Relationship between Backtest and Coping Styles in Pigs. (Under the direction of Joe Cassady).

The objective of this study was to examine relationships between the Backtest (BT) and coping styles in pigs. The BT was performed on 575 piglets from 75 litters; once at six and again at 13 days of age. For this test, pigs were placed in the supine position for 60 seconds. The amount of time struggling and the number of struggle attempts during each test were recorded. The times and number of struggles from each test were combined to give total time struggling (TTS) and total struggle attempts (TSA). Pigs were ranked within replicate (n=5) based on TTS. Piglets in the top (high TTS; n=60) and bottom (low TTS; n=60) 10 percent of their respective replicates were selected for additional behavior tests. The additional tests chosen were the Novel Object Test (NOT) to measure response to novelty, Resident Intruder Test (RIT) to gauge aggression, and maze test to evaluate cue usage. Other researchers have suggested that these traits reflect underlying coping styles in rodents and pigs. The NOTs were performed at five and again at six weeks of age. For NOT and RIT, half of the pigs' home pen was sectioned off with a solid divider to form an isolated test area. One pig, from that pen, was placed in the test area and a novel object was introduced. Latency to begin exploring and time exploring an object were recorded and summed to give total latency to explore (TEXLAT), and total time exploring (TTEX). Heart rates of individual pigs were recorded during NOT by fitting the pigs with Polar S610i heart rate monitors and Wearlink transmitter straps (Polar Electro Oy, Finland) prior to being placed in the test arena; heart rates were used to evaluate cardiac response to novelty. The RITs were

performed two days after each NOT. A resident pig, was placed in the test area and an unfamiliar, intruder, pig from a non-neighboring pen was introduced. Latency for resident to contact intruder, time from first contact until attack, and time of attack were recorded and summed to give total latency to contact (TCONLAT), total time from contact to attack (TCONTOATT), and total time to attack (TATTLAT). Time to complete a maze trial and errors performed were measured in six trials; four training and two test trials. Trials were conducted three days per week when pigs were seven to eight weeks old. In addition to behavior traits, adjusted 21-day weight (A21dwt) and preweaning average daily gain (pADG) were calculated from farrowing and weaning ages and weights. Correlations were calculated among all behavior and production traits. Only the following correlations were significant ($P < 0.05$): TTS with TSA, pADG, and A21dwt, TCONTOATT with TATTLAT and TCONLAT, TEXLAT with TTEX, , and pADG with A21dwt. Differences in cardiac response during the NOT, RIT, and maze performance between high and low groups were analyzed in SAS using linear models, with sex, replicate, and group as fixed effects, and Wilcoxon Rank Sum Tests, using group as class variable. No consistent differences in performance were found when comparing high and low pigs. It was concluded that performance during BT is not related to behavioral or cardiac response during the NOT, aggression, or cue usage as measured by tests used in this study. Results of the present study do not support the theory that BT performance is indicative of coping styles in pigs.

Relationship between Backtest and Coping Styles in Pigs

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BIOGRAPHY

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CHAPTER 1
LITERATURE REVIEW

Introduction

It is widely known that individual animals of all species respond differently in stressful situations. However, an abundance of research has shown that in mice, rats, and several other species, individuals' responses fall into two distinct categories, referred to as coping styles (Koolhaas et al., 1999). By breeding rodents based on outcomes of specific behavior tests, strains of animals that reliably exhibit distinct coping style characteristics have been successfully created (Benus et al., 1991).

Research has been done investigating the possibility of distinct coping styles in domestic animal species, including pigs. Although some studies are conflicting, many scientists believe coping styles, similar to those found in mice and rats, to be present in pigs (Hessing et al., 1993; Koolhaas, 2008; Koolhaas et al., 1999). If reliable tests of coping styles in pigs were found, perhaps lines with different coping styles could be created and producers would be able to select animals that would adapt well to their management conditions.

The backtest is commonly used to measure behavioral response of piglets to an imposed stressful situation (Hessing et al., 1993; van Erp-van der Kooij et al., 2001). Although this test frequently appears in pig studies, the specific characteristics being measured are uncertain (Jensen, 1995). Many studies view the backtest as an indicator of coping style (Hessing et al., 1994; Hessing et al., 1993); however, others disagree with this view (Jensen, 1995; Jensen et al., 1995a).

This review serves to provide brief summaries of several topics: tests and characteristics of coping styles in rodents, coping style characteristic tests in pigs, backtest, and past research on backtest as measure of coping style.

What is a Coping Style

Many definitions of coping can easily be found in the literature, ranging from specific to general. Lazarus et al. (1974) viewed coping in humans as “problem-solving efforts made by an individual when the demands he [or she] faces are highly relevant to his [or her] welfare (that is, a situation of considerable jeopardy or promise) and when these demands tax his [or her] adaptive resources.” In other words, coping can be viewed as a reaction to a situation in which an individual feels threatened in some way. Levine and Wiener (1989) suggest that coping is a response “based on reduction of pathological or physiological indices.” Wechsler (1995) simply states “coping behaviour is a response to aversive situations.” Another definition presented by Koolhaas et al. (1999) is “behavioral and physiological efforts to master the situation.” Although worded differently, these definitions all view coping as a response by the individual to a disturbance. Since stress is defined as the disruption of homeostasis by an intrinsic or extrinsic, physical or psychological force (Avitsur, 2006) coping refers to the response by the animal to stress in this review.

Expanding the idea of coping, a coping style is generally defined to be “a coherent set of behavioral and physiological stress responses which is consistent over time and which is characteristic to a certain group of individuals” (Koolhaas et al., 1999). That is, if a group’s coping response is reliable over time and similar situations, those animals would be said to

exhibit a coping style. Existence of coping styles is heavily supported in mice and rats, but less evidence has been reported in pigs.

Henry and Stephens (1977) popularized the theory of the presence of two types of coping styles. Names of the two styles differ between articles, but characteristics of the styles are consistent. Originally described as the “fight-flight response”, one coping style is most commonly known as “active response” (Koolhaas et al., 1999). However, since some of the behavioral characteristics of “active response” style are not what some would consider active, this style is also referred to as “proactive” (Koolhaas et al., 1999). The second coping style is sometimes known as “conservation-withdrawal response” (Engel and Schmale, 1972). It is commonly referred to as “passive response” (Koolhaas et al., 1999). As with the first coping style, the notion of “passive” can be misleading, therefore, this coping style is also referred to as “reactive.” For clarity, the two coping styles will be labeled proactive and reactive for the remainder of this review. Both the behavioral and physiological attributes that differentiate these coping styles are described in the literature.

Coping Styles in Mice And Rats

Numerous studies have provided extensive evidence for the existence of distinct coping styles in mice and rats. These coping styles, proactive and reactive, have been shown to exist across many test situations.

Behavioral Tests and Characteristics of Coping Styles

The foremost attribute that distinguishes the proactive and reactive coping styles in mice and rats is their general behavioral approach to handling a stressful situation. This division is described in great detail by Benus et al. (1991). They state that proactive rodents

take a more dynamic approach, actively attempting to get rid of or escape the stressor, or gain control of the situation. Reactive mice and rats take a passive approach to stress. These different methods are exemplified by numerous tests and specific behaviors.

Attack Latency and Resident Intruder

The main behavioral characteristic that distinguishes proactive and reactive coping styles in mice and rats is aggression levels. Rodents with proactive coping style are shown to be more aggressive while reactive rodents are less aggressive (Benus et al., 1991). Most experiments use lines that have been specifically bred over generations to be either highly or lowly aggressive. The most common lines of mice used are the short-attack-latency (SAL) line and long-attack-latency (LAL) line.

Selection for these lines described by Oortmerssen and Bakker (1981) in a study where performance in the attack latency test was measured. In this test, a mouse was familiarized with a cage so that it became the mouse's home cage; this mouse will be referred to as the resident mouse. Several days after the resident mouse was placed in the cage, a transparent divider was placed in the cage. After the resident acclimated to the wall, a novel mouse was introduced on the opposite side from the resident. The time from the introduction of the novel mouse, to the time when the mice met at the wall was measured and referred to as the "meet latency." The divider was then removed and the time until an attack, "attack latency," were measured. If an attack did not occur within 10 minutes, the test was ended. Mice that were quick to attack their opponent, ones with short attack latency, were labeled as more aggressive. Mice slow to attack, or that showed no attacks, long attack latency mice, were labeled less aggressive. Oortmerssen and Bakker (1981) successfully selected for short

attack latencies for 11 generations. Other studies have shown similar results in selecting for attack latency aggression in mice (Benus et al., 1991).

A popular variation of the attack latency test is the resident intruder test, described by de Boer et al. (2003). To prevent atypical behavior due to isolation, the animal is housed with a companion. Shortly before the introduction of the novel animal, the companion is removed from the cage. As in the attack latency test, the time until an attack occurs is measured and used to evaluate aggression levels. Studies of coping style in mice and rats look for correlations between aggression level and other behaviors that indicate coping styles.

Shock Prod / Defensive Burying

Another common distinction between proactive and reactive coping styles is appearance of a fight-flight versus withdrawal-freeze response to a stressor. These responses are frequently elicited in the “shock prod,” also known as “defensive burying,” test. The protocol for this test is described by Pinel and Triet (1978). A mouse or rat is placed in an enclosure either with or without bedding on the floor, depending on what characteristic is being tested. The bedding can be familiar or novel, in regards to material or freshness. A shock prod is introduced to the enclosure, delivering a shock to the subject whenever contact occurs. The rodent’s reaction to the prod is recorded. Most rodents’ responses can be categorized as active or passive. Slutyer et al. (1996) defines the categories as the active response consists of burying the prod with the bedding (defensive burying), and less frequently, rearing. Passive response includes the subject freezing, becoming immobile, and grooming.

In a study by Slutyer et al. (1996) aggression in SAL and LAL mice were evaluated in a modified version of the attack latency test. Mice were then put through the defensive burying test to determine whether they expressed an active or passive response. Mice were tested once in a cage with bedding from their home cage, and again in a cage with fresh bedding. Results showed that SAL, aggressive, mice displayed more active and less passive behaviors compared to LAL mice in both situations. It was also noted that LAL mice occasionally reacted in an active manner when they were in a cage with familiar bedding. This demonstrates that LAL mice are capable of reacting similarly to SAL mice, but change their reaction in different environments. Results from a study by Sgoifo et al. (1996) showed similar a similar trend. The level of aggression in a version of the attack latency test was highly correlated with amount of burying behavior in the shock prod test. Similar results were found in a later experiment by Slutyer et al. (1999), in which increased display of active response to the shock prod test was also found to be consistent across genders. This correlation was again supported by de Boer and Koolhaas (2003) who took the extra step to conclude that the active response of defensive burying in the shock prod test is an indicator of the subject's proactive coping style, whereas the passive response of freezing/immobility indicates a reactive coping style.

Active Shock Avoidance

Another method of testing for fight-flight versus withdrawal-freeze response is active shock avoidance, described by Benus et al. (1989). For this test, an individual is placed in a shuttle box apparatus, which is an enclosure with two compartments and a partial divider between them. The floor on one side of the box is wired so that shocks can be delivered to

the animal's feet. To conduct the active shock avoidance test an animal is first tested for a "shock threshold," shock level at which a response is elicited. After the threshold has been established, the subject was trained via classical conditioning to go over the barrier into the other compartment in response to a light being turned on, to avoid receiving a shock. Since the subject must actively remove themselves from the shock half of the box, this test should differentiate mice with fight-flight responses from those with withdrawal-freeze responses. The responses of SAL and LAL mice were compared in this study. It was found that SAL mice showed more successful shock avoidances than LAL mice. Supporting the idea that aggressive mice are active responders.

Similar to development of SAL and LAL mouse lines, Roman-High (RHA) and Roman-Low (RLA) Avoidance rat lines were developed based on response to the active shock avoidance test (Driscoll et al., 1998). RHA rats were quicker to learn how to avoid shocks, and had more successful shock avoidances, while RLA rats were less successful at avoiding the shock, and exhibited more freezing and grooming behavior. Based on their responses in the active shock avoidance task, RHA rats are considered to have proactive coping style and RLA rats have reactive coping. However, it is noted that RHA and RLA rats also have different levels of emotional reactivity and therefore, are not as widely used to study coping styles as the SAL and LAL mice.

Open Field

A common test of the reaction of mice and rats to a novel environment is the open field test. For this test, a subject is placed in the center of a large, empty, well lit area (Steimer and Driscoll, 2005). Latency of subject to move from the start position, amount of

locomotion activity, and grooming behavior are some parameters commonly measured. When comparing RHA and RLA rats, it was found that RLA subjects had longer latencies to move from start position, less locomotion activity, were quicker to start grooming, and showed more grooming behavior overall when compared to the RHA subjects (Steimer and Driscoll, 2005). In the comparison of SAL and LAL mice, LAL mice exhibited less locomotion activity than SAL mice in an open field test (Veenema et al., 2003).

Maze

Adaptability of mice and rats to changing environments is also used to discern proactive and reactive coping styles. These characteristics are commonly evaluated in maze tests. Benus et al. (1987) conducted a series of maze tests on mice and rats to examine several behaviors. Before being tested in the mazes, aggression of the mice and rats was evaluated using an attack latency test. In the first maze test, mice and rats were individually trained to run through one maze configuration to a goal box with a food reward until they could complete it without error within a set time limit of 15 seconds. After the criteria were met, external maze cues were changed by rotating the maze 90 degrees relative to environment. Subject was given one run through this altered maze. The maze was then returned to its original position and training recommenced until criteria were met again. A piece of tape was then stuck to floor of the maze in a specified location to alter internal maze cues. Again, the subject was given one run in the altered maze. In a second maze test, mice and rats were taught how to get to the goal box from the start box with several very simple maze configurations. After training, mice were tested in 12 different maze configurations.

Time to reach the goal box and number of errors made were recorded for all runs in both maze tests.

Results of the Benus et al. (1987) tests, showed that more aggressive and less aggressive animals are affected by cue changes and maze formation changes differently. More aggressive animals were less distracted by environmental changes. They showed a smaller increase in completion time and number of errors in response to changes in extra- and internal maze cues. Less aggressive animals were more highly influenced by changes in cues, showing significant increases in time and errors. In the first maze test it was also found that less aggressive animals did not display as much of a linear decrease in completion time and errors as aggressive animals on repeated maze runs. This difference was attributed to increased exploratory behavior of less aggressive animals in later runs. Conversely, less aggressive animals adapted better to the changing maze configurations in the second maze test. More aggressive animals performed significantly more errors, indicating that they rely more on intrinsic routines than the less aggressive animals.

A more common maze test is the “Y-maze.” It was utilized in a study by Benus et al. (1990) to further examine routine formation in aggressive versus non-aggressive, SAL versus LAL, mice. Y-maze consists of a home cage connected to a Y-shaped tube. At the end of each arm of the Y are identical cages containing food and water. A subject is placed in the home cage and allowed to acclimate to the maze. After adjusting, one arm of the maze is closed off so that subject can only access food and water in one arm. After a period of time, the closed arm is reopened and previously open arm is closed. If the subject entered the closed arm, that previously led to food and water, it was considered an error. Benus et al.

(1990) found that LAL had significantly higher activity levels after maze arm closure reversal than SAL mice. SAL mice also had significantly higher percentage of errors for several days following reversal compared to LAL mice, indicating that aggressive mice had more trouble adapting to the changed environment. This finding supports the idea that aggressive animals, which would have proactive coping styles, form more routine-like behavior compared to their less aggressive counterparts.

A summary of behavioral characteristics differentiating proactive and reactive rodents can be found in Table 1. When behavioral characteristics of coping styles are combined it can be said that proactive animals, such as SAL mice and RHA rats, attempt to control the environment by being active when faced with a stressor, while reactive animals, like LAL mice and RLA rats, do not seem to attempt to exert control over the environment, instead exhibiting passive responses (Bohus et al., 1987). Because proactive animals attempt to gain control and are more likely to form rigid routines, they are better suited to stable environments than reactive animals. Flexibility of reactive individuals allows them to adapt to changing environments more easily than proactive individuals (Koolhaas et al., 1999).

Physiological Characteristics of Coping Styles

As previously stated, it is important to note that coping styles differ in behavioral and physiological responses to stressful situations. Experiments with procedures outside the scope of this review have shown differences between proactive and reactive coping mice and rats in regards to physiological and endocrine responses to stress, as well as basal hormone levels.

Proactive, SAL mice had lower plasma corticosterone, indicating decreased HPA-axis reactivity, in response to a stressful situation compared to LAL, reactive, mice (Korte et al., 1996; Veenema et al., 2003). Rats that exhibited proactive coping styles also showed increased plasma catecholamines in a stressful situation in comparison with reactive coping style rats (Sgoifo et al., 1996). Fokkema et al. (1988) found that proactive rats exhibit higher baseline catecholamine levels in addition to having larger norepinephrine responses to stress. High levels of catecholamines, epinephrine, and norepinephrine, indicate high sympathetic nervous system activity. Effects of sympathetic nervous system activity prepare animals for the fight-or-flight reaction (Frandsen et al., 2003b).

Studies have shown that proactive animals have increased heart rate, tachycardia, in response to a stressful situation compared with reactive animals which tend to exhibit decreased heart rate, bradycardia (Bohus et al., 1987). While tachycardia is a sign of increased sympathetic nervous system activity, bradycardia indicates parasympathetic nervous system activity (Frandsen et al., 2003b). Therefore, proactive animals exhibit higher sympathetic nervous system activity and reactive animals show more parasympathetic activity.

Differences in neurotransmitter levels were also found between proactive and reactive animals. Proactive mice and rats were found to show high dopamine reactivity while reactive animals exhibited low dopamine (Koolhaas, 2008). Korte et al. (1996) found that in addition to differing in HPA-axis reactivity and corticosterone levels, SAL mice had higher levels of serotonin.

A summary of physiological differences between proactive and reactive coping styles in mice and rats can be found in Table 2.

Health Issues Related to Coping Styles

It is common knowledge that stress can lead to health problems in most species. It is also known that an individual's reaction to the stressor can influence the development of those health problems. Studies have shown that, in some situations, an individual animal's coping style may put the animal at a higher risk of developing certain health issues ranging from mild to severe. Many testing techniques used to examine differing susceptibility are outside the scope of this review.

A study by Fokkema et al. (1988) found that rats displaying more aggression during a resident-intruder test had higher blood pressure during testing compared to less aggressive rats. Another study, in which a resident-intruder test was performed to determine aggressiveness in rats, found aggressive individuals had higher blood pressure readings while at rest (Fokkema et al., 1995). It was concluded that more aggressive animals exhibit higher blood pressure in general compared to their less aggressive peers.

Immune system activity is a topic that has been studied by numerous researchers. Sandi et al. (1991) examined activity of several types of lymphocytes, white blood cells, in RHA versus RLA rats. It was found that RHA rats had lower lymphocyte activity than RLA rats. This difference was increased when rats were exposed to stressful situations. Teunis et al. (2004) focused on one type of lymphocytes, natural killer (NK) cells, and their correlation with dopamine system activity. Results showed that rats with higher dopaminergic reactivity had lower NK cell activity compared to rats with lower

dopaminergic reactivity. Both studies found proactive rats to have lower immune system activity under testing conditions (Sandi et al., 1991; Teunis et al., 2004).

Sternberg et al. (1989) examined susceptibility to streptococcal cell wall (SCW) arthritis in rats exhibiting different levels of HPA-axis reactivity. It was found that rats with lower HPA-axis reactivity were more likely to develop SCW arthritis than rats with high reactivity. A study by Kavelaars et al. (1999) looked for a correlation between susceptibility of rats to experimental autoimmune encephalomyelitis (EAE) and performance during a resident-intruder test. It was found that animals with shorter attack latencies had more severe cases of EAE than those with longer attack latencies. In both of these studies, proactive individuals, those with decreased HPA-axis reactivity and more expression of aggression, were the animals most affected by the diseases.

As previously stated, proactive animals attempt to remove or escape stressors, while reactive animals do not seem to try and obtain control of the situation. Ulcer formation in rats exposed to avoidable versus unavoidable shock situations was examined by Weiss (1972). The expected result, that rats unable to predict or avoid shocks developed more ulcers, was found. In addition, it was noticed that the more attempts the rats made during unavoidable shock, the more ulceration occurred. Rats actively trying to escape shock, proactive individuals, formed more ulcers than passive animals under similar conditions.

Tumor formation and growth have also been shown to differ between animals exhibiting different coping styles. Teunis et al. (2002) studied tumor growth and development, in response to implantation of cancerous cells, in rats with differing levels of dopaminergic system reactivity. It was found that rats with hyperdopaminergic reactivity

developed smaller tumors, had fewer cancerous growths in the lungs, and had reduced blood supply to existing tumors. A study done by Vegas et al. (2006), looked for an association between social stress and aggression, with tumor development. In this study, a modified version of a resident-intruder test was used to measure aggression in mice injected with cancer cells. It was found that mice responding to the test with passive behaviors had more tumor development than those that were more active. These studies indicate reactive coping style animals are at higher risk for tumor development.

Studies of health issues comparing proactive and reactive coping style individuals have uncovered susceptibility differences between the animals. Proactive coping style animals were shown to have higher blood pressure and decreased immune system activity, in addition to being more susceptible to SCW arthritis, EAE, and ulcer formation compared to reactive animals. Conversely, reactive coping style animals are at greater risk of tumor formation and development.

Coping Styles in Pigs

Copious research studies have detailed behavioral and psychological attributes distinguishing proactive and reactive coping styles in mice and rats. Many behavioral and physiological tests used in pigs are believed to measure characteristics similar to those differentiating coping styles in mice and rats. Some of these tests are summarized below.

Behavioral Tests of Coping Styles

Aggression

One of the main characteristics distinguishing proactive and reactive coping styles in mice and rats is aggression (Benus et al., 1991). Aggression levels can be evaluated in pigs

with several tests. One type of aggression test is the social confrontation test which measures pig aggression in groups (Hessing et al., 1995; Hessing et al., 1993). In this test, a few piglets from one litter are placed into a crate with a few piglets from another litter and the behavior of all piglets is observed, simultaneously, for 30 minutes. Frequency of behaviors (sniffing, threat, head knock, biting, fighting, chasing, fleeing, withdrawal, passive, and fight initiative) are used to classify piglets individually as aggressive or non-aggressive. Validity of using the social confrontation test was questioned by Jensen et al. (1995b). It was pointed out that behavior of an individual in a group can be influenced by behavior of others in the group. Instead of accurately measuring an individual's aggression, outcomes may instead be measuring "social interactions or social relationships."

To avoid group bias, a resident intruder test is commonly used to evaluate aggression in pigs. Procedures for testing in pigs were adapted from aggression tests in rodents by Erhard and Mendl in 1997 (D'Eath and Pickup, 2002). For the test, a portion of a litter's home pen is sectioned off via a solid divider to create a test area. Pigs from the home pen litter, "residents," are placed in the test area individually. An "intruder" pig from an unfamiliar litter is placed in the test area with the resident. Interaction of pigs is observed for up to 5 minutes, preferably no more than 3.5 minutes. As soon as an attack occurs, or when time expires, whichever occurs first, the pigs are separated and returned to their original pens. During testing, time of first contact and time of attack are recorded. The initiator of the attack was also noted; if both pigs bit each other simultaneously it was considered a "fight" (Erhard and Mendl, 1997). Attack occurrence and "attack latency," time from first contact to attack, are used to classify pigs as aggressive or non-aggressive in many studies.

Presence of attack and decreased latency were criteria to label pigs as aggressive (D'Eath and Pickup, 2002). Use of a pig's home pen and selecting intruders of approximately equal or slightly smaller body size compared to residents helps insure the test measures aggressiveness of the resident instead of the intruder (D'Eath and Pickup, 2002; Erhard and Mendl, 1997). It has been shown that testing individuals on consecutive days could have a priming effect on responses (D'Eath and Pickup, 2002; Erhard and Mendl, 1997). Therefore, pigs should not be tested on consecutive days.

Response to Novelty

Response to novelty is another characteristic that distinguishes rodents with different coping styles. Similar to mice and rats, an open field test can be used to measure this characteristic in pigs. For testing, pigs are removed from their home pens and individually placed in a novel environment. Behavior is recorded for duration of the test, typically 5 to 10 minutes. Behaviors include locomotion, standing motionless, eating or drinking, urinating or defecating, and vocalizations (Giroux et al., 2000; Hessing et al., 1994; Jensen et al., 1995a).

Another novel environment test commonly used in pigs is the open door test. For this test, instead of placing a pig in a new area, the door of the home pen is opened. Pigs are allowed to exit and enter the adjoining novel area. Latency of pigs to exit home pen and locomotion in a novel environment are commonly recorded behaviors (Ruis et al., 2000; van Erp-van der Kooij et al., 2002).

A novel object test can also be used to measure response to novelty. This test can take place in a pig's home pen (van Erp-van der Kooij et al., 2002), a sectioned off portion of a home pen, similar to the area created for resident intruder testing (Forkman et al., 1995), or

in a novel setting (Hessing et al., 1994; Jensen et al., 1995a; Spoolder et al., 1996). Novel object tests are commonly performed in combination with open field and open door tests (Hessing et al., 1994; Jensen et al., 1995a; van Erp-van der Kooij et al., 2002). Tests can be performed with individual pigs (Hessing et al., 1994; Jensen et al., 1995a; Spoolder et al., 1996), or groups (van Erp-van der Kooij et al., 2002). For individual tests a pig is placed into the test area and allowed a short adjustment period, this time is typically the novel environment test. Behaviors of the pig(s) are recorded in response to novel object introduction for duration of testing, between 3 and 15 minutes (Forkman et al., 1995; Ruis et al., 2001). Behaviors recorded vary between studies, but often include latency to contact object, duration of object exploration, and vocalization (Forkman et al., 1995; Hessing et al., 1994; Ruis et al., 2001; van Erp-van der Kooij et al., 2002).

A variation of novel object tests is the human approach test. Similar to novel object tests, human approach tests can be done with groups or individuals, occur in home pens or novel environments, and are often combined with other behavioral tests such as open field. Instead of introducing an object, a human enters the test area and, normally, remains still for duration of testing, which can be 1 to 5 minutes. During the test, behaviors including pigs' latency until and duration of contact with person are recorded (Giroux et al., 2000; Janczak et al., 2003; Ruis et al., 2000; van Erp-van der Kooij et al., 2002). This is a variation of the Hemsworth Test which evaluated sows' approach behavior towards humans (Hemsworth et al., 1986).

Routine Formation

Another characteristic distinguishing proactive and reactive coping styles in mice and rats is routine formation. Mazes are commonly used to examine this characteristic in rodents and are occasionally utilized with pigs. Bolhuis et al. (2004) used a “T-maze” to study behavioral flexibility in pigs, which is similar to the Y-maze previously discussed for mice. A T-maze consists of a corridor which branches into left and right arms, forming the “T” shape. At the end of each arm is a 90-degree turn to a short corridor where food troughs are located; the turn before the trough area prevents troughs from being seen from the branching point of the first corridor. The maze is “divided” into 10 imaginary sections so location of pigs could be referenced. In this study, pigs were deprived of food for 12 hours before testing. Food rewards were located in either the left or right maze arm. Half of the pigs tested were trained with food in the left arm, the others with food in the right arm. Pigs were individually directed from their home pens to the start box located at the main corridor end farthest from the branch point. A removable guillotine door separates this box from the remainder of maze. Each pig was guided through the maze to the food reward once. Pigs were then trained, via a series of trials, to run through the maze to the food reward. For each trial, a pig entered the start box and after 5 seconds the guillotine door was removed to allow entrance to the maze corridor. Maximum time allowed to reach the food was 3 minutes, plus 1 minute for pigs to eat. If a pig did not reach the food within the allotted time it was lead to the food and allowed to eat. If a pig crossed a division “line” in the wrong direction, i.e. down incorrect arm with at least 2 legs, it was considered an error. Pigs completed 2 to 5 trials per day until “stable task performance” criteria were met. The criteria were to complete

9 consecutive “correct” trials. Correct trials meaning pig completed maze within 15 seconds, with no errors, and ate the food.

After stable task performance criteria were met, an internal maze change was introduced. This change was a novel object placed in the arm containing the food reward. During this trial pigs were given 5 minutes to reach their food reward. Following the test trial, the object was removed and pigs went through 5 normal training trials. After the second training period, pigs ran 6 consecutive reversal trials, in which the food reward was placed in the opposite arm from its training location. A reversal trial was considered correct if pigs did not enter the arm previously containing the food reward. During all trials the following measurements were recorded: latency to reach food reward, number of errors, number of vocalizations, and frequency of defecation. Time spent in section containing the novel object was recorded for the internal maze change trial. In the first reversal trial, frequency and duration of snout contact with original food reward trough were also recorded.

Several behavior tests used in pigs measure characteristics similar to those that distinguish proactive and reactive coping styles in mice and rats. These cross-species characteristics include aggression, response to novelty, and routine formation.

Physiological Tests of Coping Styles

Studies have shown proactive and reactive rodents to differ in sympathetic nervous system versus parasympathetic nervous system activity (Koolhaas et al., 1999). Cardiac response to stressful situations was one characteristic used to measure these nervous systems’ activity in mice (Bohus et al., 1987). This characteristic has also been examined in several pig studies. Helsing et al. (1994) and Ruis et al. (2001) measured changes in pigs’ heart rates

during open field and novel object tests. Prior to testing, a chest band was fastened around the pig and a heart rate monitor was attached to the band. The chest band contained electrodes along with a sensor and transmitter. Heart rates were transmitted to, and stored in the monitor every 5 seconds throughout both tests (Hessing et al., 1994). Monitors used in both studies were from Polar Electro OY, Finland; the monitor models were Polar Sport Tester (Hessing et al., 1994) and Vantage NV (Ruis et al., 2001).

HPA-axis reactivity during exposure to stressors was also used to distinguish coping styles in mice and rats (Koolhaas et al., 1999). Cortisol levels during stressful situations, related to HPA-axis reactivity (Frandsen et al., 2003a), have been examined in pig studies. Ruis et al. (2000) measured saliva cortisol levels shortly before and after open door and human approach testing. Similarly, another study measured saliva cortisol levels immediately before and twice after, with a short delay between tests, combination open field and novel object tests (Ruis et al., 2001). Hessing et al. (1994) measured blood cortisol levels just before and 90 minutes after open field and novel object testing. Differences between salivary and blood cortisol levels are outside the scope of the current review and will not be discussed.

Many tests in pigs measure characteristics similar to those distinguishing proactive and reactive coping styles in mice and rats. These characteristics are behavioral, such as aggression and response to novelty, as well as physiological, like cardiac reactivity. A summary of tests listed in this review and characteristics they measure are provided in Table 3.

Backtest

The backtest is commonly used in studies to evaluate pig behavior during a stressful situation, on an individual basis (Hessing et al., 1993; van Erp-van der Kooij et al., 2001). For this test a piglet is placed in the supine position for 60 seconds while gently restrained. For restraint, experimenter places one hand over upper body of the pig and the other gently on the hind legs. Each struggle of the piglet is counted as an escape attempt. The number of escape attempts is recorded to calculate backtest scores (Cassady, 2007; Hessing et al., 1993; van Erp-van der Kooij et al., 2000); duration of struggle attempts is also recorded in some studies (Cassady, 2007; Velie et al., 2009). In the first published study using backtests, piglets were backtested five times total over the first three weeks after farrowing (Hessing et al., 1993). Classifications of piglets were: “resistant (R)” if they made more than two escape attempts in a backtest, “intermediate” if exactly two attempts were made, and “non-resistant (NR)” if less than two attempts were made. Upon analysis of this study, it was found that only two backtests are needed to adequately categorize piglets as R or NR. The two tests are generally performed roughly one week apart (Cassady, 2007; van Erp-van der Kooij et al., 2000; van Erp-van der Kooij et al., 2001). It was a concern that piglets’ positions, sleeping versus suckling, etc, before a backtest could influence their backtest scores. Van Erp-van der Kooij et al. (2001) found no influences of starting position, time of day, or test order on backtest scores.

The backtest has been shown to be low to moderately repeatable and moderately to highly heritable (Cassady, 2007; Velie et al., 2009). Several studies have found backtest scores to be associated with production traits. Van Erp-van der Kooij et al. (2000) found

backtest score to have positive relationship with lean meat percentage and carcass grade at slaughter. Backtest score was also associated with preweaning average daily gain (ADG), weaning weight, and ADG from 20 to 76 days of age (Cassady, 2007). Another study found backtest scores to be correlated with 21day weight ($r = -0.14$ to -0.19), ADG before weaning ($r = -0.15$ to -0.19), and back fat ($r = 0.08$ to 0.15) (Velie et al., 2009).

Backtest as Measure of Coping Styles

The backtest as an indicator of coping styles in pigs is highly debated (Hessing et al., 1993; Jensen et al., 1995b). This association between the backtest and coping styles originated from correlations between backtest scores and performance of piglets on behavior tests, measuring characteristics thought to be similar to those distinguishing proactive and reactive coping styles in mice and rats (Hessing et al., 1993). Subsequent studies have produced both similar and opposing results, leading to the current debate. A brief overview of the results of some of these studies is provided.

Studies Supporting Backtest as Measure of Coping Styles

The backtest (BT) was first proposed as a measure of coping styles in pigs in a study by Hessing et al. (1993), in which social confrontation tests (SC) and BTs were performed. SC tests were performed when piglets were 1 week old and again 1 week later. During Social confrontation tests, piglets were qualitatively classified as “aggressive (A)” or “non-aggressive (NA)” by observers, based on frequencies of some previously mentioned behaviors. Backtests were performed once during the first week after birth, twice during the second week, and 2 more times the third week. Pigs were weaned at 30 days of age. For BTs, piglets that made more than 2 escape attempts were classified as “resistant (R),” those

with less than 2 attempts were “non-resistant (NR)” It was found that 74.4% of piglets labeled as A or NA during SC1 were subsequently found to be classified as R and NR, respectively, during BTs. For SC2, 75.6% of piglets were labeled as A and R or NA and NR. If only piglets consistently classified as R and NR over all 5 BTs were analyzed, 84.4% were labeled as A and NA in social confrontation test 1, and 85.3% in test 2.

In a later study (Hessing et al., 1994), A/R and NA/NR pigs were subjected to open field (OF) and novel object (NO) tests. The BTs, SC tests, and weaning occurred at the same ages as pigs in the previous study (Hessing et al., 1993). Open field and NO tests were combined into a single 10 minute test, with a NO being introduced to the area after 5 minutes. The combination tests were performed on individual pigs at 3 weeks of age and again at 8 weeks. During the OF portion of tests, A/R pigs were less vocal than NA/NR pigs. In NO portion of tests A/R pigs had shorter latencies to contact object; however, NA/NR pigs showed more interest in the object after initial contact, demonstrated by increased time in contact with object. Cardiac response to backtest, OF, and NO tests along with cortisol levels before and after OF and NO tests were also recorded during this study. Mean heart rate of A/R pigs was higher than that of NA/NR pigs for both BT1 and BT2. For 1 minute after OF testing began, A/R pigs had higher mean heart rate than NA/NR pigs. During the next 4 minutes, mean heart rates did not differ significantly. In response to introduction of NO, A/R pigs showed considerable increase in heart rate while NA/NR pigs exhibited little increase, with heart rate of some individuals even decreasing. As with OF portion of test, mean heart rates differed significantly for only 1 min after NO introduction, and were similar over the subsequent 4 minutes. Plasma cortisol samples were collected from pigs before and

90 minutes after OF/NO tests. Before tests 1 and 2, A/R pigs had significantly lower cortisol level than NA/NR pigs. After tests 1 and 2, levels in A/R and NA/NR did not differ.

Comparing before and after measures for test 1 showed A/R pigs had substantial increase in cortisol levels while levels in NA/NR pigs did not change. Before and after measures for test 2 revealed levels for A/R pigs did not differ; however, levels in NA/NR pigs notably decreased.

A study by Ruis et al. (2000) also produced results supporting the notion of coping styles in pigs. Pigs were evaluated in BTs, open door (OD), and human approach (HA) tests; with exception of BT, tests were performed on groups of pigs. Backtests were conducted once when pigs were 2-4 days of age, and again when they were 4 weeks old. Piglets were weaned at 4 weeks of age. Similar to other studies, OD and HA tests were performed as 2 parts of a single test. This test was executed at 10 and again at 24 weeks of age. Saliva cortisol levels were also collected before and after OD/ HA tests. Based on BTs, pigs with less than 3 escape attempts were classified as “low resistant (LR),” those with more than 4 attempts were “high resistant (HR).” Results of the study showed LR pigs had longer latency to exit home pen during both OD tests compared to HR pigs. Low resistant pigs also had longer latency to contact human during first HA test than HR pigs. Cortisol response, determined by comparing cortisol levels from before and after OD and HA testing, was significantly higher for LR pigs, during the first test. Levels were not different for test 2.

A later study by Ruis et al. (2001) compared behavior of LR and HR pigs in additional test situations. In addition to a BT between 2 and 4 days of age, pigs went through OF and NO tests, individually, in response to which salivary cortisol and cardiac responses

were recorded. Similar to previous studies, OF and NO tests were combined into a single, 15 minute test, conducted at 8 weeks of age; with NO introduced after 10 minutes.

Vocalization during NO test was the only behavioral difference between LR and HR pigs during OF and NO testing; HR pigs vocalizing more. High resistant pigs also showed higher heart rate variability compared to LR pigs during testing. Low resistant pigs had higher cortisol responses, when comparing levels from before and after testing.

Bolhuis et al. (2004) utilized a T-maze to evaluate routine formation in pigs. Pigs were classified based on outcomes from 2 backtests done at 10 and 17 days of age. If pigs performed at least 2 escape attempts during 1 test and more than 4 total between both, they were labeled HR. Pigs were LR if they had less than 4 attempts between both tests and had no more than 2 attempts on an individual test. High resistant and LR pigs were then subjected to a T-maze beginning at 8 weeks of age. The maze task consisted of 3 parts, training (acquisition), internal maze change, and reversal learning. No difference in acquisition of maze was found between HR and LR pigs. Backtest score did have an influence on reaction to internal maze change; however, this influence was an interaction with housing environment also tested in this study. Reversal learning was significantly influenced by backtest score, with LR pigs being more successful at learning the new route than HR pigs.

Overall, pigs with high backtest scores, R/HR pigs, and those with low scores, NR/LR, differed both behaviorally and physiologically in many studies. The R/HR pigs were more aggressive, had decreased latency to explore novel environments, objects and people, spent less time in contact with novel objects, and were less successful at reversal

maze learning than NR/LR pigs in these studies. Level of vocalization of R/HR versus NR/LR pigs during novelty tests varied between studies. Mean heart rate of R/HR pigs was higher than NR/LR pigs during backtesting and first minute of OF testing. The R/HR pigs had a greater increase in mean heart rate for the first minute of the NO test while NR/LR individuals showed little increase and even some decrease. They also exhibited higher overall heart rate variability during OF and NO tests. Cortisol response to novelty also varied between studies, but seemed to be generally lower in R/HR pigs. Behavioral and physiological characteristics of pigs presented in these studies indicate R/HR pigs tend to exhibit proactive coping styles, while NR/LR pigs have more reactive coping styles.

Studies Not Supporting Backtest as Measure of Coping Styles

Aggression is a main distinguishing characteristic for proactive and reactive coping styles in rodents (Benus et al., 1991). For this reason, many studies of coping styles in pigs focus on aggression levels. Forkman et al. (1995) conducted a multi-experiment study examining coping styles in pigs by looking for correlations between BT score and aggression, evaluated by resident intruder (RI) testing. In experiment 1, a BT was performed at approximately 2 weeks of age. For experiment 2, 5 BTs were performed, once per week, from 1 until 5 weeks of age. Piglets were not labeled based on BT performance as is done in other studies. Instead, number of escape attempts, grunts, and squeals were recorded for each pig during each test. Piglets were weaned at 8 weeks of age. Resident intruder tests, performed at 9 weeks of age, lasted 10 minutes, and did not end early if an attack occurred. Latency to attack along with number of snout contacts and bites were recorded. No

significant correlations were found between number of escape attempts during BTs and attack latency or number of bites during RI tests.

D'Eath and Burn (2002) also conducted a study to look for correlations between BT and RI test performance. Backtests were executed when pigs were 3 and 9 days old. Pigs were classified as LR if they had less than 5 struggles (escape attempts) total over 2 BTs, and HR if they had more than 6. Resident intruder tests were conducted on 12 and 14 days post-weaning, and pigs were weaned at approximately 30 days. Resident Intruder tests lasted a maximum of 5 minutes, with pigs being separated immediately if an attack occurred. Attack occurrence and latency, measured from time of first snout contact to time of attack by resident, were recorded. Results showed no difference between LR and HR pigs in attack occurrence or latency for either RI test individually, or combined.

Another test comparing BT and RI test performance was done by Cassady (2007). First BT was conducted when pigs were 6 to 10 days of age, second performed between 13 and 17 days of age. Number and duration of escape attempts were recorded during 2 BTs. Performances during both tests were combined to form BT scores, from total number of attempts, and total time spent struggling. Piglets were weaned around 20 days of age. Resident intruder tests were performed at approximately 33 and 44 days of age. Maximum test time was five minutes. If an attack occurred, the test was immediately ended and the pigs were separated. Attack occurrence and latency were recorded; as with BTs, attack occurrences were combined for both RI tests to give a total resident intruder score. No significant phenotypic correlation between backtest score and resident intruder score was found.

Velie et al. (2009) measured pigs' performances during BT, RI, HA, and NO tests. A BT was performed when piglets were between 7 and 14 days of age, with a second test occurring one week later. Number of escape attempts and duration of struggles were recorded. Piglets were weaned between 23 and 37 days of age. Resident intruder test 1 was conducted when pigs were 31 to 53 days old; test 2 from 38 to 60 days, with at least 1 week between tests 1 and 2. Attack occurrence and latency until attack occurred were recorded. As in Cassady (2007) total number of escape attempts in both BTs and total attacks in RI tests were combined to form total number of attempts to struggle and resident intruder score, respectively. First HA and NO tests were conducted with groups of pigs in their home pens, at approximately 150 and 170 days of age, respectively, with the second of each test occurring no less than 1 week later. In HA test, latency for each individual pig to make snout contact with human was recorded. Similarly, latency to contact object was recorded in NO test. Maximum time in both tests was 5 minutes. No significant correlations were found between either of the BT measures and behavior measured in RI, NO or HA tests.

Summary

Coping style is generally defined as responses to stressors that help an individual cope with that stress (Koolhaas et al., 1999). Presence of distinct coping styles in mice and rats has been demonstrated by numerous studies. These coping styles, proactive and reactive, differ both behaviorally and physiologically in response to stress. Behaviorally, proactive animals actively try to remove or escape stressors while reactive animals tend to freeze. In accordance with their behaviors, proactive animals seem to have more active sympathetic nervous systems in response to stress, preparing them to fight or flee the stress source. These

rodent coping styles have been shown to be consistent across time and situations. Because of this stability, scientists have been able to select individuals based on a coping style characteristic, aggression for example, and create divergent lines of mice and rats that reliably express one coping style over the other. Many studies in rodents have found associations between individuals' coping styles and susceptibility to health issues ranging from decreased immune response to tumor development.

Even though presence of distinct coping styles in pigs has not been as thoroughly investigated as in mice and rats, it is heavily supported (Koolhaas et al., 1999). This is based on the abundance of behavioral and physiological tests in pigs measuring characteristics similar to those used to distinguish proactive and reactive coping styles in rodents, such as aggression and cortisol levels.

The backtest is a frequently used behavior test in pigs. It has been shown to be repeatable and moderately heritable (Cassady, 2007). Studies have also shown backtest performance to be correlated with economically important production parameters (Cassady, 2007; van Erp-van der Kooij et al., 2000). However, the characteristics actually being measured by the test are unclear. A common, although debated, theory is that the backtest is a measure of underlying coping styles in pigs. Evidence for this idea comes from correlations between pigs' actions during backtests and those from other behavior tests believed to measure coping style characteristics. However, many studies have produced results that conflict with this notion. Therefore, the relationship among the backtest and coping style remains unresolved.

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CHAPTER 2

RELATIONSHIP BETWEEN BACKTEST AND COPING

STYLES IN PIGS

Introduction

Individuals of all species are subjected to stressful situations at some point in their lives. However, the manner in which individuals cope with those stressors, whether internal or external differ. Research in several species, especially mice and rats, has shown that individuals' responses can be grouped into one of two coping styles. These two coping styles, proactive and reactive, differ both behaviorally and physiologically. Proactive individuals are more aggressive, adopt more active behaviors to escape or eliminate stressors, quickly form inflexible routines, are quicker to investigate novel stimuli, show lower hypothalamic-pituitary-adrenal (HPA) axis reactivity, and have higher sympathetic nervous system reactivity (Koolhaas et al., 1999). Conversely, reactive individuals are less aggressive, display more passive behaviors when faced with stressors, depend on environmental cues instead of routines, are more hesitant to begin exploring novel stimuli, spend more time exploring novel stimuli, have higher HPA axis reactivity, and show higher parasympathetic reactivity (Koolhaas et al., 1999).

Studies have investigated the presence and characteristics of coping styles in pigs. Many behavioral and physiological tests used to measure coping styles in pigs are similar to those tests used in mice and rats. The backtest is one of the common tests used to measure pig performance, although it is dissimilar to mice and rat tests. It has been shown to be moderately repeatable, moderately to highly heritable, and correlated with production traits (Cassady, 2007; van Erp-van der Kooij et al., 2000; Velie et al., 2009). However, the backtest is not comparable to any behavior tests used to measure coping styles in mice and rats. Past studies have attempted to investigate the backtest as an indicator of coping style,

but results of these studies are conflicting. The objective of this study was to examine relationships between the backtest and coping styles in pigs.

Materials and Methods

Description of Animals

Pigs in this study were born in five farrowing batches (replicates) with two weeks between batches, over a 66 day period at North Carolina State University Swine Education Unit, Raleigh NC. Sows farrowed in crates and piglets were processed and weighed within 24 hours after birth. Piglets were cross-fostered when necessary to create approximately equal sized litters for sows that farrowed within 48 hours of each other. Weaning occurred at approximately 21 days of age, and weight was again measured at this time. After weaning, pigs were moved to the nursery and penned in groups of 10. The nursery pens were 6 feet by five feet. Each pen contained four nipple waterers and two feeders, with one and a half feet of feeder space per feeder. Temperature and ventilation of nursery rooms were controlled to maintain comfortable levels for the pigs. Pigs in this study, selected for further testing were grouped according to backtest classification. All other pigs were grouped according to weight. Pigs were provided ad libitum access to feed in the nursery. Pigs were given one week to adjust to the nursery before additional tests were started.

Backtest

Pigs (n=575) were backtested twice, once at six and again at 13 days of age following the procedures described by Hessing et al. (1993). During the backtest (BT), pigs were lightly restrained in a supine position for 60 seconds. An experimenter placed one hand loosely on the pig's neck and the other hand was used to gently extend the hind legs. Each

wriggle, involving at least one hind leg, was counted as a struggle attempt. If a pig was still struggling at the end of the testing time, the test period was extended until the struggle attempt ended. Struggle attempts (SA) and time struggling (TS) were recorded during each backtest. Measures from BT one and BT two were combined to give total struggle attempts (TSA) and total time struggling (TTS) for each piglet (Cassady, 2007). Piglets were ranked by TTS, within each replicate, so that the top (highest TTS) and bottom (lowest TTS) 10% of pigs could be selected for additional behavior tests. Number of pigs born and selected per replicate and overall can be found in Table 4.

Novel Object Test

Novel object tests (NOT) were performed on all selected pigs twice at approximately five and six weeks of age, with one week between tests. Procedures for conducting the NOT were adapted from Forkman et al. (1995) and van Erp-van der Kooij et al. (2002). Half of the pig's home pen was sectioned off to create a test area that was approximately three feet by five feet. Solid dividers were secured to two sides of the area to prevent contact between the pig being tested and other pigs. Pigs were isolated in the test area for two minutes before a novel object (NO) was introduced; a plastic bucket for NOT1 and a tennis shoe for NOT2. After NO introduction, latency to contact object (EXLAT), each contact event, and duration of each contact event were recorded during a five minute test. Pigs were not allowed to continue exploring the object after five minutes. If a pig did not contact the object at any point during the test it was considered to have an exploration score of zero and given a latency to contact of five minutes and one second. Pigs that did explore the object were given an exploration score of one. Duration of contact events during a test were summed to

give time exploring object (TEX). EXLAT, exploration score, and TEX for each NOT1 and NOT2 were summed to give total latency to contact (TEXLAT), total exploration scores, and total time exploring (TTEX) object.

Cardiac Response to Novelty

Heart rates of individual pigs were recorded during NOT using Polar S610i heart rate monitors and Wearlink transmitter straps (Polar Electro Oy, Finland) according to procedures in previous studies (Hessing et al., 1994; Lewis et al., 2008). The Wearlink straps consisted of a chest band with built-in electrodes and a detachable transmitter to send heart rate data wirelessly to the receiver, the Polar S610i watch; a picture of the heart rate monitor apparatus can be found in the Appendix. Immediately prior to being isolated in the testing area, a Wearlink strap was securely fastened around the pig's chest. A monitor attached by a strap on the pig's back, was started. The pig was restrained until a heart rate reading appeared on monitor, and then placed in the test area. Monitors were set to record heart rate measurements every five seconds.

Additional home pen heart rates were recorded for pigs in replicates three through five. After NOT was completed, pigs were replaced with their pen mates. Heart rate recording continued for an 10 additional minutes in an attempt to obtain baseline heart rates.

Resident Intruder Test

Resident Intruder tests (RIT) were performed at five and again at six weeks of age, exactly two days after NOT each week. Pigs were tested in a sectioned off test area of home pens, with the same set up as NOT, as described by Erhard and Mendl (1997). A resident pig was placed individually into the test area of its home pen. An intruder pig of smaller size

from a pen not adjacent to the pen of the resident pig was placed into the test area. Pigs used as intruders were pigs backtested but not selected for additional tests. Latency to first snout contact, of the intruder by the resident (CONLAT), and latency to attack (ATTLAT) were recorded. Time from contact until attack (CONTOATT) was calculated by subtracting CONLAT from ATTLAT. Pigs were separated immediately if an attack occurred. An attack involved a sudden, rapid series of head knocks and or bites to the other pig (D'Eath and Burn, 2002). If no attack occurred within three minutes of intruder introduction, the test was ended, pigs were separated (Velie et al., 2009), and resident pig was given an attack score of 0 and ATTLAT of three minutes and one second. When an attack did occur, pigs were given attack scores of 1. Intruder pigs could be used once per resident, and a maximum of two times total. If an intruder initiated an attack it was not used again. The CONLAT, CONTOATT, attack score, and ATTLAT measurements from RIT1 and RIT2 were combined, respectively, to give total contact latency (TCONLAT), total time from contact to attack (TCONTOATT), total attack scores, and total attack latency (TATTLAT).

Maze Test

Maze design and procedures were based on mice and rat study by Benus et al. (1987). The maze was located in a separate building from the nursery, was constructed of plywood walls, and measured approximately eight feet x eight feet x two feet. Corridors were approximately two feet wide to allow room for pigs to turn around. The floor consisted of two sheets of subflooring secured together, covered with indoor/outdoor carpet. The maze included a start corner, where all pigs were placed into the maze, end corner, where food reward was located, six invisible error zones, and a designated spot to introduce changes in

internal maze cues. Prior to testing selected pigs, a few trials were conducted with non-selected pigs in which several food choices were offered in order to choose an appealing reward. The food options provided were cookies, bananas, apples, oatmeal cream pies, milk replacer (used for piglets), and the normal nursery ration. The pigs' normal nursery ration was the food chosen most often, and was used in all maze trials with selected pigs. To increase motivation to reach food reward, feeders were removed from test pig pens for approximately eight hours prior to each maze trial.

Maze trials were conducted when pigs were seven to eight weeks of age. Trials were held three days per week, with at least one day between trials, for two weeks. All pigs were placed in the start corner of maze so that they were facing toward food reward corner with backend touching walls of the start corner. The first three trials were training, so that pigs could become accustomed to the maze environment and learn the location of the food reward. For trial four, external maze cues were changed by rotating the maze 90 degrees relative to the environment. Trial five was another training trial, with maze returned to its original position, to reacclimate pigs. Colored tape was used to create a star shape on the floor of maze to change internal maze cues during trial six. Time to reach the food reward and number of errors committed were recorded for each maze trial. If a pig crossed into an error zone with both front legs it was counted as an error. If a pig did not reach the food reward after 10 minutes, it was removed from maze, counted as not completed and assigned a time of 10 minutes and one second. If a pig completed the maze trial within the allotted time it was assigned a completion score of 1, if not it was given a score of 0. Diagram of the maze configuration can be found in Figure 1.

It was observed that many pigs in replicates one and two hesitated to go all the way to the food reward in the finish corner the maze. Therefore, it was decided to cut down the wall at the finish corner (indicated in Figure 1; picture of modification can be found in the appendix) so that pigs would not have to walk into an enclosed area to receive their reward.

A video camera was attached to the ceiling of the building in which the maze was located. It was positioned over the center of the maze so that all parts of the maze could be seen on a computer connected to the camera. The camera was to be used to record all maze trials of pigs for later review if necessary. However, due to technological issues, only pigs in replicates three through five were able to be recorded. Within those replicates where the camera was recording, the maze trials of several pigs were not recorded to the computer correctly and therefore could not be reviewed.

Production Parameters

As part of routine facility procedures, pigs in this study were weighed at birth (birth weight, BW) and again at weaning (weaning weight, WW), approximately 21 days of age. These weights were used to calculate preweaning average daily gain and adjusted 21-day weights using the following formulas:

$$\text{Prewriteaning Gain} = WW - BW$$

$$\text{Prewriteaning Average Daily Gain (pADG)} = (\text{Prewriteaning Gain}) \div (\text{Age at Weaning})$$

$$\text{Adjusted 21-Day Weight (A21dwt)} = (\text{pADG} * 21) + BW$$

A timeline of all tests performed, weight collections and ages at which they were performed can be found in Figure 2.

Statistical Analysis

Three pigs were not used in all test analyses due to various circumstances including disappearing from test facility and injury. If available, data from these pigs were used for individual test analysis but were not used in correlation or repeatability calculations. When analyzing the heart rate data, if it appeared that the monitor malfunctioned, evidenced by a heart rate with no fluctuation for an extended period of time, or extremely low heart rate, data were excluded from analysis for that specific test. Two pigs from NOT1 and six pigs from NOT2 were excluded from respective analyses for this reason.

Distributions of some test variables were heavily skewed. Log and square root transformations were utilized to shift these distributions toward normality for analysis. If neither transformation brought the distribution closer to normality the original distribution was used for analysis. Original and transformed distributions of variables can be found in the Appendix.

Heart rates were recorded after pigs were placed back with pen mates in some replicates in attempt to obtain baseline heart rates. However, pigs' heart rates did not level out as anticipated. Therefore, heart rate baselines for each individual pig were calculated by averaging the heart rate recordings from 60 to five seconds prior to introduction of the novel object for NOT1 and NOT2 separately. Differences between pigs' individual heart rate recordings and their baselines were calculated for 19 specific time points. Those time points included all five second interval recordings for the first minute after NO introduction, beginning at five seconds after, because previous research indicated main difference between High and Low pigs occurred during this time frame (Hessing et al., 1994). In addition,

differences were calculated at 30 second intervals from 90 to 270 seconds after NO introduction.

In addition to analyzing time to complete maze trial and errors during trials, differences between maze trials were also examined. Time and error differences between consecutive maze trials were calculated and analyzed to see if High and Low pigs displayed differential changes between trials. After initial analysis of maze data, it was decided to go back and change the maximum time for maze completion to three minutes in an attempt to achieve results similar to those presented in the mice and rat maze study (Benus et al., 1987). The recorded maze trial videos were reviewed to obtain error numbers during only the first three minutes of each trial. Because maze trial videos were only available for pigs in replicates three through five, only 66 pigs were able to be included in this additional analysis. These shorted maze trials will be referred to as B maze trials while the 10 minute maximum maze trials will be referred to as A maze trials. If removal of the wall at the finish corner of the maze did have an effect on the behavior of the pigs in replicates three through five, compared to those in replicates one and two, this effect would be evident in differences between replicates.

Data were analyzed using several different methods with SAS (SAS Inst. Inc., Cary, NC). Pearson correlation coefficients were calculated for all behavior traits, pADG, and A21dwt using CORR procedure. Exploration, attack, and completion scores were analyzed using FREQ procedure to calculate chi-squared values. All other variables were analyzed using the MIXED procedure. Fixed effects for BT data, when analyzing data from all pigs (n=575), were sex and replicate. BT data with only those pigs selected for additional

behavior tests (n=120), NOT, RIT, and maze test data were analyzed using fixed effects of sex, replicate and group. Where group is pig's classification based on TTS; High or Low. When group was included as a fixed effect, an interaction of group and replicate was also included in the model. Least-squares means (LSMeans) of group and group by replicate interactions were requested along with differences between the LSMMeans were requested for all variables analyzed in MIXED.

Additional analyses, using the same models, were performed on subsets of the data using only pigs that had object exploration, attack, or maze completion scores of one. For these analyses, each test event and the overall sum of the events of each behavior test were analyzed separately, where appropriate.

Data were transposed so that measurements from individual test events were listed as repeated measures for each pig. Pig was then added to the respective models as a random variable so that variance due to the individual pig could be calculated. Repeatability was then calculated by dividing variance due to pig by total variance.

Data was also analyzed using the Wilcoxon Rank-Sum test, the SAS numerical equivalent of the Mann-Whitney U test. This test was chosen due to skewness of the data, and also this analysis method is often used in behavioral studies. This method tests for differences between medians of two populations. Observations from both populations are combined and then arranged in increasing numerical order for the variable specified. Based on this order, observations are assigned a rank; averages of ranks are used if observations tie. The sums of these ranks are then used to compare the populations (McCall, 1994). However,

because this test is based on the sums instead of the means, it can be influenced by unbalanced data.

Results

Repeatability of TS, SA, EXLAT, TEX, CONLAT, CONTOATT, and ATTLAT were 0.34, 0.13, 0.14, 0.36, 0.07, 0.18, and 0.10, respectively. P-Values of fixed effects for all behavior traits, when looking at all pigs backtested and all selected pigs in the other behavior tests, are provided in Table 5a. P-Values for the fixed effects when only considering pigs selected for additional testing for the BT, those that explored the object during NOTs, pigs in RITs where attacks occurred, and those that completed maze trials within the maximum times are presented in Table 5b. Correlations between behavior traits from BT, NOT, and RIT, and production traits are provided in Table 6a. Traits within tests were highly correlated ($P \leq 0.01$). Production traits were highly correlated with each other ($P \leq 0.01$). Total time struggling during the BT was negatively correlated with pADG ($P \leq 0.01$) and A21dwt ($P \leq 0.05$). Traits from NOT and RIT were not correlated with the production traits. Correlations between maze traits and all other traits are provided in Table 6b. The correlations between maze traits and other traits varied between maze trials with few significant correlations.

Backtest

LSMeans of BT traits, from the MIXED procedure, for those pigs selected for additional behavior tests can be found in Table 4. High and low pigs differed significantly ($P \leq 0.05$) overall and within each replicate.

Results from the Wilcoxon Rank-Sum test, presented in Table 7, are approximately the same as those found using the MIXED procedure.

Novel Object Test

All Selected Pigs

LSMeans of NOT traits for all selected pigs are provided in Table 8a. When looking at pigs from all replicates combined, high and low pigs did not differ in latency to or time exploring the NO, during either testing event, nor for the combined, overall values. However, some group by replicate interactions were found. High pigs spent more time exploring the NO than low pigs during test one in replicates one ($P \leq 0.10$) and five ($P \leq 0.05$). In contrast, low pigs were found to spend more time exploring the NO during test one in replicate four ($P \leq 0.10$), during test two in replicates three ($P \leq 0.05$) and four ($P \leq 0.01$), and when looking at total time exploring from both tests combined in replicates three ($P \leq 0.05$) and four ($P \leq 0.01$). Latency to contact the object was longer for high pigs compared to low pigs during test one in replicate four ($P \leq 0.10$).

Results from the Wilcoxon Rank-Sum test of NOT traits (Table 9) are similar to those found using MIXED. Overall, high and low pigs did not differ in EXLAT, TEX, TEXTLAT, or TTEX. High pigs took longer to explore NO during NOT1 in replicate four ($P \leq 0.10$), during NOT2 in replicate five ($P \leq 0.05$), and when looking at overall NOT in replicate five ($P \leq 0.10$). Low pigs spent more time exploring the object during NOT1 in replicates two ($P \leq 0.10$) and four ($P \leq 0.01$), during NOT2 in replicates three and four ($P \leq 0.05$), and looking at overall time exploring in replicates three and four ($P \leq 0.05$). High pigs had longer TEX

during NOT1 in replicates one and five ($P \leq 0.05$), during NOT2 in replicates one and two ($P \leq 0.10$), and overall in replicate one ($P \leq 0.10$).

NOT exploration score frequencies and associated chi-squared values are presented in Table 10. No significant frequency differences between high and low pigs were found.

Only Pigs that Explored the Novel Object

When the analysis of NOT traits was performed only on those pigs that explored the object during each test, some of the differences between high and low pigs changed (Table 8b). Overall, high and low pigs still did not differ significantly for either trait. High pigs still had longer latency to contact the object in replicate four during test one ($P \leq 0.10$). High pigs spent more time exploring the NO than low pigs during test one in replicates one ($P \leq 0.10$) and five ($P \leq 0.05$), during test two in replicate two ($P \leq 0.05$), and when looking at total time exploring NO in replicates one ($P \leq 0.10$) and five ($P \leq 0.10$). Low pigs explored the NO more during test one in replicate four ($P \leq 0.10$), during test two in replicates three ($P \leq 0.01$) and four ($P \leq 0.05$), as well as total time exploring object in replicates three ($P \leq 0.01$) and four ($P \leq 0.05$).

Resident Intruder Test

All Selected Pigs

LSMeans of RIT traits for all selected pigs are presented in Table 11a. Overall, high and low pigs did not significantly differ in latency to contact the intruder, time between contact and attack occurrence, or latency to contact. However, when looking at high and low pigs within replicate, some differences were found. Pigs classified as low took longer to

make contact with an intruder pig in replicate three during RIT1 ($P \leq 0.05$) and when looking at TCONLAT ($P \leq 0.10$). CONTOATT and ATT LAT were longer for low pigs in replicate four during RIT2 ($P \leq 0.10$).

Results of the Wilcoxon Rank-Sum analysis of RIT traits are provided in Table 12. Overall, high and low pigs did not differ for RIT traits. Low pigs had longer CONLAT than high pigs during RIT1 in replicate three ($P \leq 0.05$), longer ATT LAT and CONTOATT times during RIT2 in replicate four ($P \leq 0.10$), and longer TCONLAT in replicate three ($P \leq 0.10$). High pigs in replicate five had longer CONLAT and ATT LAT times during RIT2 ($P \leq 0.05$ and $P \leq 0.10$, respectively) and longer TATT LAT ($P \leq 0.10$).

Attack score frequencies and associated chi-squared values can be found in Table 13. Overall, high and low pigs did not differ in the percentage of pigs that attacked. However, in replicate five, during RIT2, significantly more low pigs versus high pigs attacked during testing ($P \leq 0.01$).

Only Pigs that Had an Attack Occurrence

Table 11b shows RIT LSM means for only those pigs that attacked during testing. Again, high and low pigs did not significantly differ for any trait overall, but did differ within replicates. High pigs in replicate two had longer latencies to contact intruders during RIT1 ($P \leq 0.05$). When looking at TCONLAT, low pigs had significantly longer times than the high pigs in replicate three ($P \leq 0.01$).

A Maze Tests (10 Minute Maximum)

All Selected Pigs

LSMeans of time to complete and errors during A maze trials, for all selected pigs are listed in Table 14a. When considering all replicates together, only errors committed during A maze trial three tended to differ between high and low pigs ($P \leq 0.10$). More differences were found between high and low pigs within replicates. Low pigs had longer finishing times during A maze one, in replicates three ($P \leq 0.05$) and four ($P \leq 0.01$), as well as during A maze four in replicate three ($P \leq 0.10$). High pigs had longer finishing times during A maze three, in replicate one ($P \leq 0.10$), and A maze four, in replicate five ($P \leq 0.05$). Low pigs tended to make more errors than high pigs during A maze one, in replicate five ($P \leq 0.10$), and maze six, in replicate three ($P \leq 0.01$). However, high pigs had more errors during A maze two, replicate one ($P \leq 0.10$), and A maze 4, replicate five ($P \leq 0.05$).

Results from the Wilcoxon Rank-Sum analysis of time to complete and errors during A maze trials are presented in Table 15a. Overall, high and low pigs differed in errors committed during A maze trial three ($P \leq 0.01$), with high pigs having more errors. High pigs took longer to finish A maze trial two, in replicate one ($P \leq 0.10$), trial three, in replicate one ($P \leq 0.05$), and trial four, in replicate five ($P \leq 0.01$). Low pigs tended to take longer to complete A maze trial four in replicates one and three ($P \leq 0.10$). High pigs had more errors during A maze trial three, in replicates one ($P \leq 0.05$) and five ($P \leq 0.01$), as well as trial four, in replicate five ($P \leq 0.01$). Low pigs in replicate three had more errors than high pigs during A maze trials three and six ($P \leq 0.10$).

LSMeans for time and error differences between A maze trials, for all selected pigs, are provided in Table 14b. Overall, there were no significant differences between high and low pigs for time or error changes between consecutive maze trials. When comparing high and low pigs within replicates, differences in time changes between trials were found when comparing A maze one with A maze two, in replicate four, as well as comparing A maze three with A maze four, in replicates one ($P \leq 0.05$) and two ($P \leq 0.01$). Changes in errors committed between A maze three and A maze four also differed between high and low pigs in replicate one ($P \leq 0.10$).

Results of Wilcoxon Rank-Sum analysis of time and error changes between A maze trials are presented in Table 15b. High and low pigs differed for a couple of traits overall. Change in errors between A maze trials two and three tended to differ between high and low pigs ($P \leq 0.10$). Time difference between A maze trials three and four also differed between high and low pigs ($P \leq 0.05$). Within replicate, differences between high and low pigs were found for time change between A maze trials one and two in replicate four ($P \leq 0.05$), errors change between trials two and three in replicate five ($P \leq 0.05$), time change between trials three and four in replicates one ($P \leq 0.05$) and two ($P \leq 0.10$), errors change between trials three and four in replicate one ($P \leq 0.05$), errors change between trials four and five in replicate two ($P \leq 0.10$), and time change between trials five and six in replicate one ($P \leq 0.10$).

Completion frequencies for A maze trials and the corresponding chi-square values are provided in Table 16. When looking at pigs from all replicates combined, more high pigs

tended to complete A maze trial four within the time limit than low pigs ($P \leq 0.10$). During A maze trial six, in replicate three, more high pigs finished the trial in time than low pigs ($P \leq 0.05$). However, in replicate five, more low pigs completed the maze compared to high pigs ($P \leq 0.01$).

Only Pigs that Completed Maze

LSMeans for A maze trials looking only at those pigs that completed the maze within the maximum time of 10 minutes are presented in Table 14c. Overall, high pigs took longer to finish and committed more errors during A maze trial three compared to low pigs ($P \leq 0.05$). More differences between high and low pigs were found within replicates. Low pigs in replicate three took longer than high pigs to finish A maze trials one ($P \leq 0.01$) and four ($P \leq 0.10$), while low pigs in replicate four took longer to complete A maze trial one ($P \leq 0.01$). High pigs took longer than low pigs to complete A maze trial three in replicate one ($P \leq 0.01$), and maze trial four in replicate five ($P \leq 0.05$). Low pigs committed more errors than high pigs during A maze trial one in replicate five ($P \leq 0.05$). However, high pigs had more errors during A maze trial three, in replicates one ($P \leq 0.10$) and two ($P \leq 0.05$), and A maze trial four, in replicates four and five ($P \leq 0.05$).

When looking at changes in time to complete and errors during A maze trials, no differences were found between high and low pigs overall (Table 14d). High and low pigs differed in completion time changes, with high pigs showing decrease and low pigs showing increase, which comparing A maze three with A maze four in replicates one ($P \leq 0.05$) and two ($P \leq 0.10$). High and low pigs also differed in time changes between A maze two and A

maze three within replicate two ($P \leq 0.10$); however, this difference was in the opposite direction. Changes in number of errors between mazes were also found to tend to differ between high and low pigs in A maze three versus A maze four, in replicate one ($P \leq 0.10$) with more errors by low pigs, and when comparing A maze two with A maze three four pigs in replicate two ($P \leq 0.01$), with high pigs having more errors.

B Maze Tests (3 Minute Maximum)

All Selected Pigs

LSMeans time to complete and errors committed during B maze trials, for all selected pigs, are presented in Table 17a. When looking at pigs from all replicates together, low pigs tended to commit more errors than high pigs during B maze trial one ($P \leq 0.10$). Low pigs took longer than high pigs to complete B maze trial four in replicate three ($P \leq 0.10$). Low pigs committed more errors than high pigs during B maze trial one in replicate five ($P \leq 0.01$). High pigs in replicate five took longer to complete and committed more errors than low pigs during B maze trial four ($P \leq 0.05$).

Results from Wilcoxon Rank-Sum analysis of time to complete and errors during B maze trials are presented in Table 18a. Overall, high and low pigs only significantly differed in errors committed during trial four ($P \leq 0.05$), with high pigs having more errors. Low pigs tended to take longer than high pigs to complete trial four in replicate three ($P \leq 0.10$). High pigs took longer than low pigs to complete trial four in replicate five ($P \leq 0.05$). Low pigs tended to make more errors than high pigs during trial one in replicate four ($P \leq 0.10$). High

pigs had more errors than low pigs during trial four in replicate five ($P \leq 0.01$) and during trial six in replicate four ($P \leq 0.10$).

High and low pigs did not differ overall or within replicate when comparing time and errors changes between B maze trials (Table 17b).

In the Wilcoxon Rank-Sum analysis of changes in time and errors between consecutive B maze trials (Table 18b), high and low pigs did not differ overall. However several differences were found within replicate. High and low pigs in replicate three tended to differ in time change between trials four and five ($P \leq 0.10$). High and low pigs in replicate five differed in errors change between trials two and three ($P \leq 0.05$), time change between trials three and four ($P \leq 0.10$), and time and errors changes between trials four and five ($P \leq 0.10$).

Completion score frequencies and chi-squared values for B maze trials are listed in Table 19. Overall, high and low groups did not differ in percentage of pigs that completed the trials within the time limit. In replicate three, there was a tendency for more high than low pigs to complete B maze trial four ($P \leq 0.10$). However, in replicate five, more low pigs than high pigs completed B maze trials one ($P \leq 0.10$), three ($P \leq 0.05$), four ($P \leq 0.01$), and five ($P \leq 0.10$).

Only Pigs that Completed Maze

LSMeans for only those pigs that completed B maze trials within time limit are presented in Table 17c. Errors committed by low pigs in replicate four during B maze trials five and six could not be calculated in this analysis. This is believed to be due to the few

replicate four, low pigs that had videos of these trials did not having any errors during the applied three minute time limit. Because of this, overall errors during B maze trials five and six for low pigs could not also be estimated. Overall, high pigs tended to make more errors than low pigs during B maze trial four ($P \leq 0.10$). Low pigs had more errors than high pigs in replicate five during B maze trial one ($P \leq 0.05$). High pigs committed more errors than low pigs during B maze trial four in replicates four ($P \leq 0.10$) and five ($P \leq 0.05$).

When looking at changes in time to complete and errors committed between consecutive B maze trials for only those pigs that completed trials within the time limit, no differences were found between high and low pigs overall or within replicates (Table 17d).

Cardiac Response to Novelty

Cardiac responses from NOT1 are presented in Table 20a (also in Figures 3a and 3b). Overall, high pigs tended to have higher mean baseline heart rates compared to low pigs ($P \leq 0.10$). In replicate two, high pigs had a significantly higher mean baseline heart rate compared to low pigs ($P \leq 0.01$). Differences between heart rates at specified time points and corresponding baselines did not differ between high and low pigs for any time point.

Cardiac responses from NOT2 are provided in Table 20b (also in Figures 3c and 3d). Results from this test differ markedly from NOT1 heart rate results. Overall, mean baseline heart rates did not differ between high and low pigs. The mean baseline of low pigs was significantly higher than that of high pigs in replicate five ($P \leq 0.05$). At 120 seconds after NO introduction, heart rate changes tended to differ between high and low pigs in replicates one, two, and three ($P \leq 0.01$). Here, in replicates one and three, the high pigs showed

positive changes in heart rate and low pigs showed negative changes, however, in replicate two, the high pigs are showing a negative change and the low pigs have the positive change. High and low pigs also differ in heart rate changes at 150 and 180 seconds after NO introduction ($P \leq 0.05$), with high pigs showing positive changes while low pigs have negative changes. At 240 seconds after NO introduction, there are differences between high and low pigs' heart rate changes in replicates three ($P \leq 0.05$) and five ($P \leq 0.10$). At this time, in replicate three, high pigs have positive changes from their baseline while low pigs have negative changes, but in replicate four, high pigs are showing negative changes and low pigs are showing positive changes. The same thing occurs at 270 seconds after NO introduction, again in replicates three ($P \leq 0.05$) and four ($P \leq 0.10$).

Discussion

The literature suggests that the backtest is a measure of coping style in pigs because it is thought to demonstrate an active attempt to escape a stressor, a characteristic of the proactive coping style (Hessing et al., 1993; Koolhaas et al., 1999). If this suggestion is true, pigs that are classified as high resisters during the backtest (High pigs in this study) should demonstrate other proactive coping style responses during other tests (Koolhaas et al., 1999). Likewise, pigs classified as low resisters (Low pigs) should exhibit reactive coping style characteristics.

If BT does measure coping style, High pigs should be quicker to approach a novel object, but spend less time exploring the object after initial contact when compared to low pigs (Hessing et al., 1994). Cardiac response to novelty should also differ between high and low pigs with high pigs showing greater increase in heart rate in response to novelty

compared to low pigs, which may even show slight decrease in heart rate (Hessing et al., 1994). These differences between High and Low pigs were not found in the current study. This lack of consistent, significant differences indicating coping styles could have several causes. One possible explanation is that the previous study performed the novel object tests in combination with open field tests, in novel environments. However, tests in this study were performed in the familiar environments of pigs' home pens. The pigs' reactions, both behavioral and physiological, to the novel object introduction in the Hessing et al. (1994) study could have been impacted by the stress of an unfamiliar location. Another possible explanation is that, in the prior study, novelty tests were performed when the pigs were at different life stages compared to pigs in this study. In the Hessing et al. (1994) study, tests were performed once before weaning and again several weeks after weaning; five weeks total between tests. However, in this study, both novel object test events were performed after piglets were weaned and occurred only one week apart. Another reason no differences were found in the current study, could be that the items used as novel objects in this study did not elicit the same novelty responses as the items in the previous study. If all pigs in this study were more or less startled by these objects than pigs in the Hessing et al. (1994) study, differences in behavior and cardiac response between High and Low pigs may not have been as pronounced.

During an aggression test, High pigs should be more aggressive than Low pigs, if they differ in coping style (Hessing et al., 1993). Results from this study did not demonstrate consistent differences in aggression between High and Low pigs. A possible explanation for this could be the specific aggression tests used in the studies. As Jensen et al. (1995)

highlighted, the aggression test used in the Hessing et al. (1993) study could be influenced by group behavior and therefore, may not be a reliable indicator of individual aggression.

However, the resident intruder test, which was used in this study, is believed to be a reliable measure of individual aggression (Erhard and Mendl, 1997).

If backtest performance is a measure of coping style, then High and Low pigs should differ in maze navigation methodology. When subjected to a maze test during which cues, that may be used to navigate the maze, are changed, Low pigs should show greater reaction to the changes, in the form of increased time to complete maze and more errors, when compared to High pigs (Benus et al., 1987). Additionally, High and Low pigs should differ in both measures of maze performance from the first trial due to the highly exploratory nature of the reactive coping style, thought to be exhibited by the Low pigs (Benus et al., 1987). Significant differences between High and Low pigs' performances during the maze trials in which cues were changed were not consistently found in this study. Similarly, High and Low pigs did not consistently differ in time or errors over all maze trials, as would be predicted in individuals with different coping styles. The lack of differences could be due to several factors. First, significant changes were made to the original procedures described by Benus et al. (1987) when adapting the maze test for pigs. Having a set number of training trials instead of advancement criteria may have prevented pigs from fully developing routines or establishing cues that would have lead to differences when cues were changed. Also, rodents in the previous study (Benus et al., 1987) were only given access to food in the goal box at the end of the maze. Conversely, pigs in this study had access to food in their home

pens at all times except the eight hours preceding maze trials. Therefore, motivation to complete the maze could have been higher in the rodents compared to the pigs.

If backtest did measure coping styles in pigs, traits from the backtest should be correlated with performance during other tests of coping style. In this study, total time struggling and total number of struggle attempts did not correlate with any of the traits measuring aggression, response to novelty, or cue usage during maze navigation.

When looking at results of the current study, consistent differences between High and Low pigs during novel object, cardiac response to novelty, resident intruder, and maze tests did not exist. When significant differences did exist they were not always in the direction that characterizes proactive and reactive copings styles. Based on these results, it does not appear that performance during the backtest is an indicator of coping style in pigs.

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Table 1. Behavioral characteristics of coping styles in mice and rats

Test	Characteristic	Proactive	Reactive	Reference
Attack latency & resident intruder	Aggression	High	Low	Benus et al., 1991; Oortmerssen and Bakker, 1981; de Boer et al., 2003
	Attack latency	Short	Long	
Shock prod/defensive burying	Behavioral response to stressor	Active	Passive	Slutyer et al., 1996; Sgoifo et al., 1996; Slutyer et al., 1999; de Boer and Koolhaas, 2003
Active shock avoidance	Success at shock avoidance	High	Low	Benus et al., 1989; Driscoll et al., 1998
Open field	Latency to move from start position	Short	Long	Steimer and Driscoll, 2005; Veenema et al., 2003
	Locomotion	More	Less	
	Grooming	Less	More	
Maze	Reliance on cues	Low	High	Benus et al., 1987; Benus et al., 1990
	Routine formation	High	Low	
	Flexibility in adjusting to change	Low	High	
	Exploration of maze	Low	High	

Table 2. Physiological Characteristics of Coping Styles in Mice and Rats

Characteristic	Proactive	Reactive	Reference
Hypothalamic Pituitary Adrenal-axis reactivity	Low	High	Korte et al., 1996; Veenema et al., 2003
Sympathetic reactivity	High	Low	
Parasympathetic reactivity	Low	High	Fokkema et al., 1988; Bohus et al., 1987
Heart rate reaction to stress	Tachycardia	Bradycardia	
Dopamine reactivity	High	Low	Koolhaas, 2008
Serotonin levels	High	Low	Korte et al., 1996

Table 3. Tests of Coping Style Characteristics in Pigs

Test	Characteristic	Reference
Social confrontation Resident intruder	Aggression	Hessing et al., 1995; Hessing et al., 1993; D'Eath and Pickup, 2002
Open field Open door Novel object Human approach	Response to novelty	Giroux et al., 2000; Hessing et al., 1994; Jensen et al., 1995a; Ruis et al., 2000; van Erp-van der Kooij et al., 2002; Forkman et al., 2005; Spoolder et al., 1996; Janczak et al., 2003
Maze	Routine Formation	Bolhuis et al., 2004
Cardiac response to stress	Sympathetic versus parasympathetic reactivity	Hessing et al., 1994; Ruis et al., 2001
Cortisol levels	HPA-axis reactivity	Ruis et al., 2000; Ruis et al., 2001; Hessing et al., 1994

Table 4. Number of Pigs in Study and Backtest LSMeans¹ for Selected Pigs

Replicate	Born	Group	Trait ³ : Selected	Test 1				Test 2				Overall ²			
				TS(s)		SA		TS(s)		SA		TTS(s)		TSA	
				Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM
1	133	High	14	28.59**	1.81	5.14**	0.37	31.52**	2.04	3.80**	0.33	60.10**	2.09	8.94**	0.54
		Low	14	7.07	1.80	1.57	0.36	4.29	2.03	1.00	0.33	11.36	2.08	2.57	0.54
2	98	High	10	37.23**	2.16	4.69**	0.44	25.63**	2.44	3.89**	0.39	62.87**	2.50	8.58**	0.65
		Low	10	10.18	2.15	2.31	0.43	4.88	2.42	1.38	0.39	15.06	2.48	3.68	0.64
3	123	High	13	36.47**	1.87	3.92**	0.38	39.62**	2.10	4.06**	0.34	76.09**	2.16	7.98**	0.56
		Low	13	10.00	1.87	1.92	0.38	5.53	2.10	1.55	0.34	15.53	2.16	3.48	0.56
4	95	High	10	40.62**	2.15	3.89**	0.43	46.52**	2.42	3.42*	0.39	87.14**	2.48	7.32**	0.64
		Low	10	7.10	2.13	1.40	0.43	11.60	2.40	2.10	0.39	18.70	2.46	3.50	0.64
5	126	High	13	42.92**	1.87	3.92*	0.38	42.38**	2.10	4.71**	0.34	85.30**	2.16	8.63**	0.56
		Low	13	12.13	1.90	2.85	0.39	5.89	2.14	1.49	0.35	18.02	2.19	4.34	0.57
Total ⁴	575	High	60	37.16**	0.89	4.31**	0.18	37.13**	1.01	3.98**	0.16	74.30**	1.03	8.29**	0.27
		Low	60	9.29	0.89	2.01	0.18	6.44	1.00	1.50	0.16	15.73	1.02	3.51	0.27

¹LSMeans have been calculated using model adjusting for sex²Overall measurements calculated by summing measurements from test 1 and test 2³TS = time struggling, SA = struggle attempts, TTS = total time struggling (sum of TS from tests 1 and 2), TSA = total struggle attempts (sum of SA from tests 1 and 2)⁴Total LSMeans have also been adjusted for replicate*Indicates significant difference between High and Low pigs at $P \leq 0.05$ **Indicates significant difference between High and Low pigs at $P \leq 0.01$

Table 5a. P-Values of Fixed Effects for All Pigs¹

Test	Test Event	Trait ³	Fixed Effect ²				Group* Replicate	Test Event	Test	Trait ³	Fixed Effect ²			Group* Replicate
			Replicate	Sex	Group	Interaction					Replicate	Sex	Group	
Backtest	1	TS	<.0001	0.09	-	-	Maze A Comparisons ⁵	1 vs 2	Time	0.08	0.63	0.73	0.15	
		SA	0.16	0.88	-	-		Errors	0.01	0.97	0.98	0.58		
	2	TS	<.0001	0.00	-	-		2 vs 3	Time	0.69	0.40	0.66	0.92	
		SA	<.0001	0.00	-	-		Errors	0.08	0.52	0.71	0.76		
	Overall	TTS	<.0001	0.01	-	-		3 vs 4	Time	0.82	0.67	0.11	0.04	
TSA		0.01	0.07	-	-	Errors	0.97	0.89	0.70	0.12				
Novel Object	1	EXLAT	0.64	0.40	0.41	0.38	Maze B ⁶	1	Time	0.47	0.05	0.44	1.00	
		TEX	0.06	0.45	0.82	0.01			Errors	0.23	0.00	0.10	0.03	
	2	EXLAT	0.77	0.93	0.21	0.49		2	Time	0.12	0.27	0.91	0.95	
		TEX	0.18	0.86	0.58	0.00			Errors	0.60	0.44	0.55	0.94	
	Overall	TEXLAT	0.62	0.77	0.16	0.50		3	Time	0.91	0.09	0.81	0.54	
		TTEX	0.16	0.58	0.64	0.00			Errors	0.04	0.55	0.27	0.69	
Resident Intruder	1	CONLAT	0.69	0.39	0.60	0.24	Maze B Comparisons ⁵	4	Time	0.62	0.40	0.57	0.02	
		CONTOATT	0.04	0.93	0.86	0.97			Errors	0.01	0.75	0.23	0.08	
		ATTLAT	0.09	0.64	0.99	0.92			Time	0.82	0.97	0.82	0.59	
	2	CONLAT	0.10	0.46	0.46	0.37		5	Time	0.82	0.97	0.82	0.59	
		CONTOATT	0.93	0.09	0.45	0.24			Errors	0.39	0.83	0.78	0.76	
		ATTLAT	0.94	0.07	0.51	0.15			Time	0.23	0.68	0.35	0.48	
	Overall	TCONLAT	0.58	0.83	0.96	0.18		6	Time	0.23	0.68	0.35	0.48	
		TCONTOATT	0.28	0.31	0.67	0.55			Errors	0.05	0.02	0.88	0.19	
		TATTLAT	0.22	0.14	0.61	0.26			1 vs 2	Time	0.35	0.23	0.39	0.99
		Errors	0.35	0.48	0.45	0.21				Errors	0.93	0.16	0.98	0.59
Maze A ⁴	1	Time	0.16	0.58	0.64	0.00	Maze B Comparisons ⁵	2 vs 3	Time	0.09	0.18	0.63	0.56	
		Errors	0.01	0.15	0.12	0.24			Errors	0.07	0.05	0.28	0.58	
	2	Time	0.05	0.25	0.69	0.50		3 vs 4	Time	0.58	0.67	0.77	0.20	
		Errors	0.61	0.57	0.81	0.39			Errors	0.36	0.31	0.63	0.84	
	3	Time	0.01	0.58	0.24	0.37		4 vs 5	Time	0.82	0.50	0.78	0.33	
		Errors	0.56	0.82	0.07	0.64			Errors	0.43	0.46	0.56	0.56	
	4	Time	0.04	0.64	0.38	0.02		5 vs 6	Time	0.20	0.68	0.56	1.00	
		Errors	0.21	0.12	0.94	0.10			Errors	0.91	0.04	0.48	0.58	
	5	Time	0.72	0.38	0.92	0.49		6	Time	0.38	0.94	0.63	0.81	
		Errors	0.22	0.26	0.80	0.74			Errors	0.38	0.94	0.63	0.81	
	6	Time	0.38	0.94	0.63	0.81		Errors	0.35	0.48	0.45	0.21		
		Errors	0.35	0.48	0.45	0.21								

¹Subset of pigs: for backtest = pigs selected for additional behavior tests (n=120); for all other tests = only pigs that did explore the object, did have an attack occurrence, or did complete maze within maximum allotted time (in each respective test)

²Fixed Effect: Group = effect of backtest group classification (high or low), Replicate = effect of farrowing group replicate, Sex = effect of sex

³Trait: TS = time struggling, SA = number of struggle attempts, TTS = total time struggling (sum of TS from test 1 and test 2), TSA = total struggle attempts (sum of SA from test 1 and test 2), EXLAT = latency to explore/contact novel object, TEX = time exploring object during test, TEXLAT = total latency to explore novel object (sum of EXLAT from test 1 and test 2), TTEX = total time exploring object (sum of TEX from test 1 and test 2), CONLAT = latency to contact intruder, CONTOATT = time from contact until attack, ATTLAT = latency to attack, TCONLAT = total latency to contact intruder (sum of CONLAT from test 1 and test 2), TCONTOATT = total time from contact to attack (sum of CONTOATT from test 1 and test 2), TATTLAT = total attack latency (sum of ATTLAT from test 1 and test 2), Time = time to complete maze trial, Errors = number of errors committed during maze trial

⁴Maze A = 10 minute maximum to complete maze trial

⁵Maze Comparisons: X vs Y = (maze trial Y) - (Maze trial X)

⁶Maze B = 3 minute maximum to complete maze trial

Table 5b. P-Values of Fixed Effects for Subset of Pigs¹

Test	Test Event	Trait ³	Fixed Effect ²				Group* Replicate Interaction	Test	Test Event	Trait ³	Fixed Effect ²				Group* Replicate Interaction
			Replicate	Sex	Group	Group					Replicate	Sex	Group	Group	
Backtest	1	TS	<.0001	0.15	<.0001	0.03	Maze A Comparisons ⁵	1 vs 2	Time	0.16	0.79	0.67	0.72		
		SA	0.20	0.91	<.0001	0.02			Errors	0.02	0.68	0.73	0.81		
	2	TS	<.0001	0.94	<.0001	0.00		2 vs 3	Time	0.73	0.32	0.08	0.38		
		SA	0.35	0.11	<.0001	0.13			Errors	0.05	0.54	0.14	0.30		
	Overall	TTS	<.0001	0.24	<.0001	<.0001		3 vs 4	Time	0.82	0.87	0.32	0.06		
TSA		0.43	0.29	<.0001	0.21	Errors			1.00	0.88	0.85	0.14			
Novel Object	1	EXLAT	0.64	0.40	0.41	0.38		Maze B ⁶	1	Time	0.23	0.16	0.94	0.43	
		TEX	0.06	0.45	0.82	0.01				Errors	0.41	0.24	0.18	0.14	
	2	EXLAT	0.93	0.43	0.26	0.49			2	Time	0.13	0.13	0.73	0.58	
		TEX	0.06	0.52	0.81	0.00				Errors	0.65	0.34	0.74	0.79	
	Overall	TEXLAT	0.93	0.75	0.16	0.69	3		Time	0.67	0.02	0.63	0.79		
		TTEX	0.12	0.30	0.86	0.00			Errors	0.66	0.98	0.50	0.90		
	Resident Intruder	1	CONLAT	0.86	0.63	0.15	0.08		4	Time	0.33	0.85	0.87	0.45	
CONTOATT			0.73	0.40	0.76	0.99	Errors			0.00	0.05	0.10	0.02		
ATTLAT			0.72	0.83	0.53	0.92	Time			0.07	0.76	0.43	0.95		
2		CONLAT	0.11	0.20	0.86	0.44	5		Time	0.42	0.76	0.63	0.92		
		CONTOATT	0.06	0.02	0.50	0.47		Errors	0.42	0.76	0.63	0.92			
		ATTLAT	0.08	0.01	0.56	0.66		Time	0.08	0.86	0.28	0.40			
Overall		TCONLAT	0.70	0.16	0.78	0.02	6	Time	0.08	0.86	0.28	0.40			
		TCONTOATT	0.33	0.35	0.57	0.69		Errors	0.49	0.76	0.25	0.59			
		TATTLAT	0.35	0.06	0.66	0.61									
Maze A ⁴		1	Time	0.41	0.42	0.47	0.00	Maze B Comparisons ⁵	1 vs 2	Time	0.28	0.85	0.65	0.40	
	Errors		0.01	0.22	0.11	0.17	Errors			0.48	0.87	0.46	0.98		
	2	Time	0.13	0.31	0.61	0.81	2 vs 3		Time	0.08	0.10	0.76	0.64		
		Errors	0.79	0.26	0.73	0.50			Errors	0.52	0.01	0.54	0.64		
	3	Time	0.13	0.33	0.03	0.03	3 vs 4		Time	0.39	0.05	0.78	0.92		
		Errors	0.88	0.48	0.02	0.43			Errors	0.95	0.08	0.87	0.47		
	4	Time	0.92	0.90	0.69	0.03	4 vs 5		Time	0.30	0.38	0.22	0.16		
		Errors	0.83	0.03	0.17	0.07			Errors	0.19	0.86	0.76	0.08		
	5	Time	0.69	0.62	0.71	0.65	5 vs 6		Time	0.14	0.92	0.91	0.43		
		Errors	0.06	0.25	0.62	0.88			Errors	0.90	0.81	0.68	0.25		
	6	Time	0.38	0.45	0.69	0.67									
		Errors	0.50	0.64	0.45	0.42									

¹Subset of pigs: for backtest = pigs selected for additional behavior tests (n=120); for all other tests = only pigs that did explore the object, did have an attack occurrence, or did complete maze within maximum allotted time (in each respective test)

²Fixed Effect: Group = effect of backtest group classification (high or low), Replicate = effect of farrowing group replicate, Sex = effect of sex

³Trait: TS = time struggling, SA = number of struggle attempts, TTS = total time struggling (sum of TS from test 1 and test 2), TSA = total struggle attempts (sum of SA from test 1 and test 2), EXLAT = latency to explore/contact novel object, TEX = time exploring object during test, TEXLAT = total latency to explore novel object (sum of EXLAT from test 1 and test 2), TTEX = total time exploring object (sum of TEX from test 1 and test 2), CONLAT = latency to contact intruder, CONTOATT = time from contact until attack, ATTLAT = latency to attack, TCONLAT = total latency to contact intruder (sum of CONLAT from test 1 and test 2), TCONTOATT = total time from contact to attack (sum of CONTOATT from test 1 and test 2), TATTLAT = total attack latency (sum of ATTLAT from test 1 and test 2), Time = time to complete maze trial, Errors = number of errors committed during maze trial

⁴Maze A = 10 minute maximum to complete maze trial

⁵Maze Comparisons: X vs Y = (maze trial Y) - (Maze trial X)

⁶Maze B = 3 minute maximum to complete maze trial

Table 6a. Pearson Correlation Coefficients for Backtest, Novel Object, Resident Intruder, and Production Measurements¹

Test	Traits ²	Backtest		Novel Object Test		Resident Intruder Test			Production Traits	
		TSA	TEXLAT	TTEX	TCONLAT	TCONTOATT	TATLAT	pADG	A21dwt	
Backtest	TTS	0.59**	0.13	-0.05	0.01	-0.03	-0.03	-0.24**	-0.19*	
	TSA		0.00	0.04	0.02	-0.08	-0.08	-0.11	-0.06	
Novel Object	TEXLAT			-0.32**	0.12	0.03	0.06	-0.12	-0.11	
	TTEX				0.03	0.04	0.05	0.11	0.10	
Resident Intruder	TCONLAT					-0.33**	0.01	-0.09	-0.09	
	TCONTOATT						0.93**	-0.02	-0.03	
	TATLAT							-0.03	-0.05	
Production Trait	pADG								0.97**	

¹For backtest correlations all backtested pigs were used, for all other tests only those pigs selected for additional behavior tests were used

²TSA = total number of struggle attempts, TEXLAT = total latency to explore novel object, TTEX = total time exploring novel object, TCONLAT = total latency for contact between resident and intruder, TCONTOATT = total time from contact to attack, TATLAT = total latency to attack, TTS = total time struggling, pADG = preweaning average daily gain, A21dwt = adjusted 21-day weight

*P<0.05

**P<0.01

Table 6b. Pearson Correlation Coefficients Between Maze Trials and All Other Measurements

		Maze A (10 Minute Maximum)											
		Maze 1		Maze 2		Maze 3		Maze 4		Maze 5		Maze 6	
Test	Traits ¹	Time	Errors	Time	Errors	Time	Errors	Time	Errors	Time	Errors	Time	Errors
Backtest	TTS	-0.05	-0.06	0.02	-0.02	0.04	0.16	-0.07	-0.02	0.03	0.03	0.06	0.02
	TSA	0.04	-0.13	0.00	-0.01	0.04	0.11	-0.13	-0.04	-0.06	-0.04	-0.04	0.11
Novel	TEXLAT	-0.32**	0.15	0.11	0.15	0.16†	0.18	0.16†	0.22*	0.21*	0.12	0.21*	0.03
Object	TTEX	1.00**	-0.24*	0.18*	0.05	0.12	-0.05	0.01	-0.04	-0.14	-0.08	0.01	-0.02
Resident	TCONLAT	0.03	-0.02	-0.07	0.00	0.07	0.03	0.14	0.00	0.09	0.01	0.15†	0.06
Intruder	TCONTOATT	0.04	-0.03	0.15	-0.01	0.15†	0.17	-0.01	-0.02	0.09	0.03	0.04	-0.13
	TATTLAT	0.05	-0.03	0.12	-0.02	0.14	0.17	0.04	-0.03	0.12	0.05	0.07	-0.09
Production	pADG	0.11	-0.22*	0.01	-0.21†	-0.18†	-0.13	-0.12	-0.06	-0.24*	0.08	-0.16†	0.19†
Traits	A21dwt	0.10	-0.25*	0.02	-0.17	-0.17†	-0.14	-0.10	-0.06	-0.23**	0.05	-0.14	0.20†

		Maze B (3 Minute Maximum)											
		Maze 1		Maze 2		Maze 3		Maze 4		Maze 5		Maze 6	
Test	Traits ¹	Time	Errors	Time	Errors	Time	Errors	Time	Errors	Time	Errors	Time	Errors
Backtest	TTS	0.15	-0.20	0.06	-0.03	0.00	0.12	0.08	0.17	0.05	0.00	0.05	-0.05
	TSA	0.03	-0.19	0.04	0.03	-0.06	-0.11	0.05	0.00	0.04	-0.05	0.12	0.10
Novel	TEXLAT	0.34**	0.04	0.24*	0.18	0.18	-0.11	0.18	0.21	0.21†	0.20	0.31**	-0.01
Object	TTEX	-0.16	-0.24	0.06	0.08	0.03	-0.15	0.13	0.07	-0.08	-0.05	-0.09	-0.14
Resident	TCONLAT	0.05	0.08	0.05	0.17	0.11	0.01	0.22†	0.01	0.15	0.00	0.40**	0.04
Intruder	TCONTOATT	0.23†	0.05	0.09	0.15	0.13	0.22	0.03	0.10	0.08	-0.11	-0.06	-0.03
	TATTLAT	0.26*	0.10	0.10	0.23†	0.13	0.23	0.10	0.11	0.14	-0.11	0.06	0.01
Production	pADG	-0.05	-0.14	0.06	0.20	-0.10	-0.19	-0.02	0.10	-0.09	0.19	-0.07	0.20
Traits	A21dwt	-0.05	-0.21	0.01	0.16	-0.07	-0.18	0.01	0.10	-0.09	0.15	-0.08	0.24

¹Time = time to complete maze trial, Errors = number of errors committed during maze trial TSA = total number of struggle attempts, TEXLAT = total latency to explore novel object, TTEX = total time exploring novel object, TCONLAT = total latency for contact between resident and intruder, TCONTOATT = total time from contact to attack, TATTLAT = total latency to attack, TTS = total time struggling, pADG = preweaning average daily gain, A21dwt = adjusted 21-day weight

†Indicates difference between High and Low pigs at $P \leq 0.1$

*Indicates significant difference between High and Low pigs at $P \leq 0.05$

**Indicates significant difference between High and Low pigs at $P \leq 0.01$

Table 7. Wilcoxon Rank-Sum Analysis of Backtest Traits, Only Pigs Selected For Additional Behavior Tests

		Test 1								
		TS				SA				
Replicate	Trait ¹ : Group	N ²	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score
Overall ³	High	60	5418.0**	3630.0	190.40	90.30	4969.0**	3630.0	187.27	82.82
	Low	60	1842.0	3630.0	190.40	30.70	2291.0	3630.0	187.27	38.18
1	High	14	301.0**	203.0	21.70	21.50	294.5**	203.0	21.47	21.04
	Low	14	105.0	203.0	21.70	7.50	111.5	203.0	21.47	7.96
2	High	10	155.0**	105.0	13.20	15.50	139.0**	105.0	12.89	13.90
	Low	10	55.0	105.0	13.20	5.50	71.0	105.0	12.89	7.10
3	High	13	260.0**	175.5	19.48	20.00	237.5**	175.5	18.92	18.27
	Low	13	91.0	175.5	19.48	7.00	113.5	175.5	18.92	8.73
4	High	10	152.0**	105.0	13.14	15.20	143.0**	105.0	13.01	14.30
	Low	10	58.0	105.0	13.14	5.80	67.0	105.0	13.01	6.70
5	High	13	260.0**	175.5	19.47	20.00	218.0*	175.5	18.87	16.77
	Low	13	91.0	175.5	19.47	7.00	133.0	175.5	18.87	10.23

		Test 2								
		TS				SA				
Replicate	Trait ¹ : Group	N ²	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score
Overall ³	High	60	5398.0**	3630.0	190.40	89.97	5194.0**	3630.0	187.69	86.57
	Low	60	1862.0	3630.0	190.40	31.03	2066.0	3630.0	187.69	34.43
1	High	14	301.0**	203.0	21.71	21.50	297.0**	203.0	21.32	21.21
	Low	14	105.0	203.0	21.71	7.50	109.0	203.0	21.32	7.79
2	High	10	155.0**	105.0	13.21	15.50	149.0**	105.0	13.03	14.90
	Low	10	55.0	105.0	13.21	5.50	61.0	105.0	13.03	6.10
3	High	13	260.0**	175.5	19.47	20.00	247.5**	175.5	18.98	19.04
	Low	13	91.0	175.5	19.47	7.00	103.5	175.5	18.98	7.96
4	High	10	151.0**	105.0	13.22	15.10	129.5*	105.0	12.69	12.95
	Low	10	59.0	105.0	13.22	5.90	80.5	105.0	12.69	8.05
5	High	13	260.0**	175.5	19.48	20.00	259.5**	175.5	19.17	19.96
	Low	13	91.0	175.5	19.48	7.00	91.5	175.5	19.17	7.04

		Overall								
		TTS				TSA				
Replicate	Trait ¹ : Group	N ²	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score
Overall ³	High	60	5430.0**	3630.0	190.44	90.50	5293.5**	3630.0	189.42	88.23
	Low	60	1830.0	3630.0	190.44	30.50	1966.5	3630.0	189.42	32.78
1	High	14	301.0**	203.0	21.73	21.50	300.5**	203.0	21.58	21.46
	Low	14	105.0	203.0	21.73	7.50	105.5	203.0	21.58	7.54
2	High	10	155.0**	105.0	13.21	15.50	147.0**	105.0	13.14	14.70
	Low	10	55.0	105.0	13.21	5.50	63.0	105.0	13.14	6.30
3	High	13	260.0**	175.5	19.45	20.00	254.5**	175.5	19.30	19.58
	Low	13	91.0	175.5	19.45	7.00	96.5	175.5	19.30	7.42
4	High	10	155.0**	105.0	13.22	15.50	147.5**	105.0	12.92	14.75
	Low	10	55.0	105.0	13.22	5.50	62.5	105.0	12.92	6.25
5	High	13	260.0**	175.5	19.49	20.00	256.0**	175.5	19.26	19.69
	Low	13	91.0	175.5	19.49	7.00	95.0	175.5	19.26	7.31

¹TS = time struggling, SA = struggle attempts, TTS = total time struggling (sum of TS from tests 1 and 2), TSA = total struggle attempts (sum of SA from tests 1 and 2)

²N = number of pigs included in analysis

³Overall LSMMeans have also been adjusted for replicate

*Indicates significant difference between High and Low pigs at $P \leq 0.05$

**Indicates significant difference between High and Low pigs at $P \leq 0.01$

Table 8a. Novel Object LSMeans¹, All Selected Pigs

		Test 1					
Trait ² :		Latency(s) ^a			Time Exploring(s) ^b		
		95% Confidence Limits			95% Confidence Limits		
Replicate	Group	Mean	Lower	Upper	Mean	Lower	Upper
Overall ³	High	10.97	9.22	13.06	54.12	48.82	59.69
	Low	8.97	7.61	10.57	55.84	50.73	61.20
1	High	9.68	6.88	13.64	74.28†	62.09	87.55
	Low	10.32	7.43	14.34	47.08	37.85	57.31
2	High	12.57	7.87	20.07	28.99	19.15	40.88
	Low	11.23	7.59	16.62	52.05	40.57	64.97
3	High	10.04	7.13	14.12	42.06	33.05	52.16
	Low	15.42	10.96	21.70	51.73	41.68	62.86
4	High	14.14†	9.36	21.35	42.93†	32.57	54.73
	Low	4.86	3.22	7.32	75.01	61.18	90.25
5	High	9.21	6.46	13.14	94.89*	81.09	109.78
	Low	6.68	4.72	9.46	55.28	44.71	66.98

		Test 2					
Trait ² :		Latency(s) ^a			Time Exploring(s) ^b		
		95% Confidence Limits			95% Confidence Limits		
Replicate	Group	Mean	Lower	Upper	Mean	Lower	Upper
Overall ³	High	14.16	11.67	17.18	60.68	52.40	69.56
	Low	10.02	8.31	12.09	67.54	59.19	76.43
1	High	9.25	6.28	13.61	89.88	70.21	111.97
	Low	11.23	7.51	16.77	57.80	42.31	75.70
2	High	27.33	16.11	46.36	99.13	71.43	131.36
	Low	9.74	6.25	15.17	46.07	30.55	64.78
3	High	12.25	8.33	18.02	22.22*	13.07	33.77
	Low	14.91	10.14	21.92	65.98	49.35	85.02
4	High	11.99	7.70	18.68	45.15**	29.80	63.69
	Low	8.84	5.69	13.72	130.66	103.61	160.83
5	High	15.32	10.42	22.53	65.25	48.72	84.20
	Low	7.02	4.67	10.55	51.07	36.36	68.29

		Overall					
Trait ² :		Total Latency(s) ^a			Total Time Exploring(s) ^b		
		95% Confidence Limits			95% Confidence Limits		
Replicate	Group	Mean	Lower	Upper	Mean	Lower	Upper
Overall ³	High	31.60	26.79	37.27	125.53	114.20	137.39
	Low	22.76	19.45	26.64	133.23	122.10	144.85
1	High	24.05	17.29	33.45	170.16	144.25	198.22
	Low	25.24	18.16	35.08	116.51	95.31	139.84
2	High	54.01	34.40	84.80	142.87	111.07	178.66
	Low	24.33	16.67	35.50	110.18	86.72	136.45
3	High	25.95	18.67	36.06	67.30*	51.44	85.29
	Low	34.05	24.50	47.32	128.02	105.75	152.43
4	High	35.68	24.45	52.07	97.43**	75.45	122.21
	Low	17.96	12.34	26.13	211.83	178.99	247.43
5	High	26.19	18.84	36.40	167.63	141.99	195.40
	Low	16.28	11.65	22.76	111.37	90.32	134.61

¹LSMeans have been adjusted for sex²Latency = time between novel object introduction and first contact of object by pig, Time Exploring = duration of object contact by pig for length of test, Total Latency = sum of Latencies from tests 1 and 2, Total Time Exploring = sum of time exploring from test 1 and test 2³Overall LSMeans have also been adjusted for replicate^aData were log transformed for analysis and backtransformed to display in this table^bData were square root transformed for analysis and backtransformed to display in this table

†Indicates difference between High and Low pigs at P ≤ 0.1

*Indicates significant difference between High and Low pigs at P ≤ 0.05

Table 8b. Novel Object LSMeans¹, Only Pigs that Explored Object

Test 1							
Trait ² :		Latency(s) ^a			Time Exploring(s) ^b		
		95% Confidence Limits			95% Confidence Limits		
Replicate	Group	Mean	Lower	Upper	Mean	Lower	Upper
Overall ³	High	10.97	9.22	13.06	54.12	48.82	59.69
	Low	8.97	7.61	10.57	55.84	50.73	61.20
1	High	9.68	6.88	13.64	74.28†	62.09	87.55
	Low	10.32	7.43	14.34	47.08	37.85	57.31
2	High	12.57	7.87	20.07	28.99	19.15	40.88
	Low	11.23	7.59	16.62	52.05	40.57	64.97
3	High	10.04	7.13	14.12	42.06	33.05	52.16
	Low	15.42	10.96	21.70	51.73	41.68	62.86
4	High	14.14†	9.36	21.35	42.93†	32.57	54.73
	Low	4.86	3.22	7.32	75.01	61.18	90.25
5	High	9.21	6.46	13.14	94.89*	81.09	109.78
	Low	6.68	4.72	9.46	55.28	44.71	66.98

Test 2							
Trait ² :		Latency(s) ^a			Time Exploring(s) ^b		
		95% Confidence Limits			95% Confidence Limits		
Replicate	Group	Mean	Lower	Upper	Mean	Lower	Upper
Overall ³	High	11.93	9.95	14.31	69.00	60.52	78.04
	Low	8.96	7.54	10.64	71.93	63.81	80.53
1	High	9.06	6.38	12.86	90.60	72.27	111.00
	Low	11.23	7.81	16.14	57.99	43.58	74.47
2	High	17.83	10.65	29.85	135.94*	103.27	173.09
	Low	6.84	4.49	10.42	56.17	39.32	76.02
3	High	12.17	8.59	17.25	22.34**	13.78	32.95
	Low	11.59	8.06	16.67	77.54	60.07	97.23
4	High	7.98	5.22	12.21	57.23*	40.07	77.43
	Low	8.84	5.94	13.15	130.66	105.57	158.41
5	High	15.42	10.88	21.86	65.05	49.72	82.43
	Low	7.34	5.07	10.60	49.82	36.31	65.45

Overall							
Trait ² :		Total Latency(s) ^a			Total Time Exploring(s) ^b		
		95% Confidence Limits			95% Confidence Limits		
Replicate	Group	Mean	Lower	Upper	Mean	Lower	Upper
Overall ³	High	27.92	23.86	32.67	136.16	124.76	148.06
	Low	20.56	17.75	23.82	138.99	128.21	150.20
1	High	23.67	17.48	32.05	171.10†	146.86	197.21
	Low	25.11	18.56	33.96	116.77	96.96	138.43
2	High	39.34	25.18	61.47	180.53	144.48	220.60
	Low	17.54	12.17	25.26	126.17	101.49	153.53
3	High	25.81	19.08	34.92	67.50**	52.66	84.19
	Low	27.54	20.11	37.72	141.22	118.49	165.94
4	High	26.80	18.55	38.72	113.97*	90.39	140.28
	Low	17.96	12.72	25.34	211.83	181.19	244.85
5	High	26.32	19.46	35.61	167.32†	143.42	193.06
	Low	16.89	12.42	22.97	109.60	90.11	131.01

¹LSMeans have been adjusted for sex²Latency = time between novel object introduction and first contact of object by pig, Time Exploring = duration of object contact by pig for length of test, Total Latency = sum of Latencies from tests 1 and 2, Total Time Exploring = sum of time exploring from test 1 and test 2³Overall LSMeans have also been adjusted for replicate^aData were log transformed for analysis and backtransformed to display in this table^bData were square root transformed for analysis and backtransformed to display in this table

†Indicates difference between High and Low pigs at P ≤ 0.1

*Indicates significant difference between High and Low pigs at P ≤ 0.05

**Indicates significant difference between High and Low pigs at P ≤ 0.01

Table 9. Wilcoxon Rank-Sum Analysis of Novel Object Test Traits

		Test 1								
		EXLAT				TEX				
Replicate	Trait ¹ : Group	N ²	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score
Overall ³	High	56	3361.0	3276.0	180.73	60.02	3309.0	3276.0	180.97	59.09
	Low	60	3425.0	3510.0	180.73	57.08	3477.0	3510.0	180.97	57.95
1	High	13	178.5	182.0	20.56	13.73	218.0*	182.0	20.59	16.77
	Low	14	199.5	196.0	20.56	14.25	160.0	196.0	20.59	11.43
2	High	7	64.5	63.0	10.16	9.21	47.5†	63.0	10.24	6.79
	Low	10	88.5	90.0	10.16	8.85	105.5	90.0	10.24	10.55
3	High	13	158.0	175.5	19.36	12.15	162.0	175.5	19.48	12.46
	Low	13	193.0	175.5	19.36	14.85	189.0	175.5	19.48	14.54
4	High	10	123.5†	105.0	13.21	12.35	73.0**	105.0	13.22	7.30
	Low	10	86.5	105.0	13.21	8.65	137.0	105.0	13.22	13.70
5	High	13	183.5	175.5	19.40	14.12	209.0*	175.5	19.49	16.08
	Low	13	167.5	175.5	19.40	12.88	142.0	175.5	19.49	10.92
		Test 2								
		EXLAT				TEX				
Replicate	Trait ¹ : Group	N ²	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score
Overall ³	High	56	3388.5	3248.0	178.52	60.51	3122.0	3248.0	178.69	55.75
	Low	60	3281.5	3422.0	178.52	55.62	3548.0	3422.0	178.69	60.14
1	High	13	159.5	175.5	19.41	12.27	202.0†	175.5	19.49	15.54
	Low	14	191.5	175.5	19.41	14.73	149.0	175.5	19.49	11.46
2	High	7	75.0	63.0	10.22	10.71	79.5†	63.0	10.24	11.36
	Low	10	78.0	90.0	10.22	7.80	73.5	90.0	10.24	7.35
3	High	13	163.0	175.5	19.47	12.54	134.5*	175.5	19.49	10.35
	Low	13	188.0	175.5	19.47	14.46	216.5	175.5	19.49	16.65
4	High	10	104.5	105.0	13.16	10.45	78.0*	105.0	13.22	7.80
	Low	10	105.5	105.0	13.16	10.55	132.0	105.0	13.22	13.20
5	High	13	210.5*	175.5	19.46	16.19	180.5	175.5	19.49	13.88
	Low	13	140.5	175.5	19.46	10.81	170.5	175.5	19.49	13.12
		Overall								
		TEXLAT				TTEX				
Replicate	Trait ¹ : Group	N ²	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score
Overall ³	High	56	3443.0	3248.0	178.66	61.48	3180.5	3248.0	178.70	56.79
	Low	60	3227.0	3422.0	178.66	54.69	3489.5	3422.0	178.70	59.14
1	High	13	168.0	175.5	19.47	12.92	208.0†	175.5	19.50	16.00
	Low	14	183.0	175.5	19.47	14.08	143.0	175.5	19.50	11.00
2	High	7	73.0	63.0	10.23	10.43	72.0	63.0	10.25	10.29
	Low	10	80.0	90.0	10.23	8.00	81.0	90.0	10.25	8.10
3	High	13	163.0	175.5	19.48	12.54	140.5*	175.5	19.50	10.81
	Low	13	188.0	175.5	19.48	14.46	210.5	175.5	19.50	16.19
4	High	10	117.5	105.0	13.22	11.75	76.0*	105.0	13.22	7.60
	Low	10	92.5	105.0	13.22	9.25	134.0	105.0	13.22	13.40
5	High	13	201.5†	175.5	19.46	15.50	199.0	175.5	19.50	15.31
	Low	13	149.5	175.5	19.46	11.50	152.0	175.5	19.50	11.69

¹EXLAT = time between novel object introduction and first contact of object by pig, TEX = duration of object contact by pig for length of test, TEXLAT = total latency to explore object (sum of EXLAT from test 1 and test 2), TTEX = total time exploring object (sum of TEX from test 1 and test 2)

²N = number of pigs included in analysis

³Overall LSMMeans have also been adjusted for replicate

†Indicates difference between High and Low pigs at P ≤ 0.1

*Indicates significant difference between High and Low pigs at P ≤ 0.05

**Indicates significant difference between High and Low pigs at P ≤ 0.01

Table 10. Novel Object Exploration Score¹ Frequency² and Chi-Squared Values

Replicate	Group	Test 1		Test 2		Overall ³				
		Score		Score		Score		Chi-Squared		
		Frequencies	Chi-Squared Value	Frequencies	Chi-Squared Value	Frequencies	Frequencies	Value		
		1	0	1	0	2	1	0		
Overall	High	100	0	96.23	3.77	0.0119	96.23	3.77	0	-
	Low	100	0	96.61	3.39		96.61	3.39	0	
1	High	100	0	100	0	-	100	0	0	-
	Low	100	0	100	0		100	0	0	
2	High	100	0	83.33	16.67	0.1524	83.33	16.67	0	0.1524
	Low	100	0	90	10		90	10	0	
3	High	100	0	100	0	0.9615	100	0	0	0.9615
	Low	100	0	92.31	7.69		92.31	7.69	0	
4	High	100	0	90	10	1.0526	90	10	0	1.0526
	Low	100	0	100	0		100	0	0	
5	High	100	0	100	0	-	100	0	0	-
	Low	100	0	100	0		100	0	0	

¹Exploration Score = Whether or not pig explored novel object at all during test; 1 = did explore, 0 = did not explore

²Frequency = percentage of pigs in group with specified exploration score

³Overall Exploration Score: 2 = explored object during both test 1 and test 2, 1 = explored object during test 1 or test 2, 0 = did not explore object during either test

Table 11a. Resident Intruder Test LSMeans¹, All Selected Pigs

		Test 1								
Trait ² :		Latency to Contact(s) ^a			Time Contact to Attack(s)			Latency to Attack(s)		
		95% Confidence Limits			95% Confidence Limits			95% Confidence Limits		
Replicate	Group	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper
Overall ³	High	12.05	10.40	13.96	119.97	111.87	128.07	132.92	126.02	139.82
	Low	13.45	11.64	15.54	121.98	114.02	129.94	132.86	126.08	139.64
1	High	10.50	7.82	14.10	119.20	102.99	135.41	126.19	112.38	140.00
	Low	14.95	11.15	20.04	124.00	107.87	140.13	136.93	123.19	150.67
2	High	14.14	9.76	20.48	159.81	139.44	180.18	164.71	147.36	182.06
	Low	9.36	6.60	13.27	147.22	128.00	166.44	149.33	132.95	165.71
3	High	10.91*	8.05	14.79	111.73	94.99	128.47	124.28	110.02	138.54
	Low	26.54	19.58	35.98	114.20	97.46	130.94	132.26	118.00	146.52
4	High	14.23	10.03	20.19	114.68	95.46	133.90	134.17	117.79	150.55
	Low	9.76	6.90	13.80	130.20	111.12	149.28	135.90	119.64	152.16
5	High	11.03	8.13	14.95	94.43	77.68	111.17	115.26	101.00	129.52
	Low	12.15	8.92	16.57	94.29	77.26	111.32	109.87	95.37	124.37

		Test 2								
Trait ² :		Latency to Contact(s) ^a			Time Contact to Attack(s) ^b			Latency to Attack(s)		
		95% Confidence Limits			95% Confidence Limits			95% Confidence Limits		
Replicate	Group	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper
Overall ³	High	8.15	7.18	9.26	90.22	82.28	98.53	109.09	101.58	116.60
	Low	7.12	6.28	8.08	99.20	90.97	107.78	116.23	108.82	123.64
1	High	5.26	4.08	6.79	91.34	75.72	108.42	108.03	93.01	123.05
	Low	4.28	3.29	5.57	107.71	90.16	126.83	118.39	102.88	133.90
2	High	7.62	5.54	10.50	110.81	89.33	134.60	126.18	107.31	145.05
	Low	9.60	7.10	12.98	90.43	72.17	110.75	110.95	93.14	128.76
3	High	7.81	6.01	10.16	83.44	68.09	100.36	100.16	84.65	115.67
	Low	9.95	7.65	12.94	109.98	92.23	129.29	130.53	115.02	146.04
4	High	9.59	7.09	12.97	69.44†	53.57	87.38	90.65†	72.84	108.45
	Low	7.69	5.70	10.37	116.62	95.89	139.37	132.20	114.53	149.88
5	High	11.99	9.22	15.59	98.81	82.03	117.16	120.45	104.94	135.96
	Low	5.83	4.46	7.62	74.38	59.69	90.69	89.09	73.32	104.86

		Overall								
Trait ² :		Total Latency to Contact(s) ^a			Total Time Contact to Attack(s)			Total Latency to Attack(s)		
		95% Confidence Limits			95% Confidence Limits			95% Confidence Limits		
Replicate	Group	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper
Overall ³	High	24.80	22.16	27.76	207.31	195.44	219.18	242.20	231.43	252.97
	Low	24.63	22.04	27.52	214.59	202.87	226.31	250.10	239.47	260.73
1	High	17.18	13.72	21.52	213.53	189.78	237.28	234.44	212.89	255.99
	Low	22.74	18.02	28.69	222.26	197.73	246.79	261.12	238.87	283.37
2	High	29.21	22.01	38.76	251.64	221.79	281.49	291.30	264.22	318.38
	Low	24.22	18.54	31.62	225.36	197.19	253.53	259.98	234.43	285.53
3	High	21.24†	16.83	26.80	197.10	172.57	221.63	224.50	202.25	246.75
	Low	38.58	30.58	48.68	209.82	185.29	234.35	262.73	240.48	284.98
4	High	28.69	21.97	37.46	184.64	156.47	212.81	225.12	199.57	250.67
	Low	20.57	15.78	26.81	244.60	216.64	272.56	268.10	242.74	293.46
5	High	30.70	24.33	38.73	189.67	165.14	214.20	235.65	213.40	257.90
	Low	20.72	16.36	26.25	170.89	145.94	195.84	198.55	175.91	221.19

¹LSMeans have been adjusted for sex

²Latency to Contact = time between intruder introduction and first contact by resident pig, Time Contact to Attack = time from first contact by resident until attack occurrence, Latency to Attack = time from intruder introduction until attack occurrence, Total Latency to Contact = sum of time between intruder introduction and first contact by resident pig from tests 1 and 2, Total Time Contact to Attack = sum of time from first contact by resident until attack occurrence from tests 1 and 2, Total Latency to Attack = sum of time from intruder introduction until attack occurrence from tests 1 and 2

³Overall LSMeans have also been adjusted for replicate

^aData were log transformed for analysis and backtransformed to display in this table

^bData were square root transformed for analysis and backtransformed to display in this table

†Indicates difference between High and Low pigs at P ≤ 0.1

*Indicates significant difference between High and Low pigs at P ≤ 0.05

Table 11b. Resident Intruder Test LSMeans¹, Only Pigs that had Attack Occurrence

Test 1										
Trait ² :		Latency to Contact(s) ^a			Time Contact to Attack(s)			Latency to Attack(s)		
		95% Confidence Limits			95% Confidence Limits			95% Confidence Limits		
Replicate	Group	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper
Overall ³	High	14.43	11.77	17.69	80.95	71.79	90.11	103.16	94.56	111.76
	Low	9.59	7.93	11.58	77.12	68.61	85.64	95.65	87.65	103.65
1	High	10.94	7.61	15.72	74.36	58.05	90.66	86.54	71.23	101.85
	Low	12.26	8.33	18.04	66.30	48.92	83.67	92.69	76.37	109.01
2	High	26.46*	12.84	54.49	87.00	54.53	119.47	113.50	83.00	144.00
	Low	3.10	1.83	5.26	91.07	67.38	114.77	98.34	76.08	120.59
3	High	10.51	7.60	14.53	91.99	77.42	106.55	107.73	94.04	121.42
	Low	20.55	14.61	28.90	83.90	68.58	99.22	110.20	95.81	124.59
4	High	18.06	11.79	27.65	74.12	54.97	93.27	105.28	87.29	123.27
	Low	9.58	6.06	15.14	78.41	57.84	98.99	90.57	71.24	109.89
5	High	11.38	8.34	15.51	77.29	63.35	91.23	102.77	89.68	115.86
	Low	10.81	7.79	15.00	65.93	51.22	80.64	86.43	72.62	100.25

Test 2										
Trait ² :		Latency to Contact(s) ^a			Time Contact to Attack(s) ^b			Latency to Attack(s)		
		95% Confidence Limits			95% Confidence Limits			95% Confidence Limits		
Replicate	Group	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper
Overall ³	High	7.82	6.83	8.94	62.03	56.39	67.95	79.89	73.83	85.95
	Low	8.10	7.03	9.34	67.95	61.69	74.50	85.17	78.75	91.59
1	High	5.34	4.14	6.89	74.47	62.98	86.93	90.66	79.20	102.13
	Low	4.73	3.57	6.27	81.02	67.79	95.42	90.37	77.69	103.04
2	High	7.55	5.47	10.41	96.03	79.61	113.99	112.56	98.07	127.05
	Low	10.73	7.93	14.51	73.48	60.02	88.29	94.35	80.73	107.96
3	High	8.14	6.14	10.78	51.90	41.44	63.55	64.03	51.36	76.71
	Low	14.20	10.04	20.07	51.07	38.48	65.44	73.90	58.32	89.48
4	High	8.69	6.44	11.72	51.28	40.26	63.63	70.08	56.60	83.56
	Low	7.68	5.26	11.21	68.38	52.40	86.47	85.74	68.72	102.75
5	High	10.24	7.42	14.12	43.38	32.60	55.70	62.13	47.65	76.62
	Low	6.31	4.92	8.09	67.68	56.99	79.28	81.51	70.32	92.70

Overall										
Trait ² :		Total Latency to Contact(s) ^a			Total Time Contact to Attack(s)			Total Latency to Attack(s)		
		95% Confidence Limits			95% Confidence Limits			95% Confidence Limits		
Replicate	Group	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper
Overall ³	High	26.04	21.96	30.88	155.01	140.75	169.27	189.46	176.62	202.30
	Low	24.26	20.28	29.03	142.77	127.78	157.76	180.92	167.42	194.42
1	High	18.78	13.94	25.29	147.51	122.62	172.40	167.64	145.23	190.05
	Low	23.63	15.95	35.01	155.00	122.13	187.88	198.75	169.15	228.35
2	High	29.93	17.17	52.20	223.00	176.51	269.49	253.00	211.14	294.86
	Low	19.13	12.68	28.85	165.90	131.53	200.27	195.04	164.09	225.99
3	High	16.84**	12.73	22.27	162.02	138.64	185.40	180.99	159.94	202.04
	Low	66.04	44.37	98.31	125.95	92.69	159.21	199.27	169.33	229.21
4	High	35.83	25.02	51.31	129.16	99.15	159.17	177.68	150.66	204.70
	Low	13.61	8.63	21.47	129.13	91.02	167.24	145.51	111.20	179.82
5	High	35.29	25.54	48.78	113.37	86.32	140.42	167.99	143.63	192.35
	Low	20.69	16.06	26.65	137.86	116.68	159.04	166.02	146.95	185.09

¹LSMeans have been adjusted for sex

²Latency to Contact = time between intruder introduction and first contact by resident pig, Time Contact to Attack = time from first contact by resident until attack occurrence, Latency to Attack = time from intruder introduction until attack occurrence, Total Latency to Contact = sum of time between intruder introduction and first contact by resident pig from tests 1 and 2, Total Time Contact to Attack = sum of time from first contact by resident until attack occurrence from tests 1 and 2, Total Latency to Attack = sum of time from intruder introduction until attack occurrence from tests 1 and 2

³Overall LSMeans have also been adjusted for replicate

^aData were log transformed for analysis and backtransformed to display in this table

^bData were square root transformed for analysis and backtransformed to display in this table

*Indicates significant difference between High and Low pigs at P ≤ 0.05

**Indicates significant difference between High and Low pigs at P ≤ 0.01

Table 12. Wilcoxon Rank-Sum Analysis of Resident Intruder Traits

		Test 1												
		CONLAT				CONTOATT				ATTILAT				
Replicate	Trait ¹ : Group	N ²	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score
Overall ³	High	59	3412.5	3540.0	187.97	57.84	3491.0	3540.0	182.26	59.17	3511.5	3540.0	182.25	59.52
	Low	60	3727.5	3600.0	187.97	62.13	3649.0	3600.0	182.26	60.82	3628.5	3600.0	182.25	60.48
1	High	14	189.5	203.0	21.64	13.54	204.0	203.0	20.65	14.57	194.0	203.0	20.65	13.86
	Low	14	216.5	203.0	21.64	15.46	202.0	203.0	20.65	14.43	212.0	203.0	20.65	15.14
2	High	9	100.5	90.0	12.23	11.17	97.0	90.0	10.10	10.78	98.0	90.0	10.10	10.89
	Low	10	89.5	100.0	12.23	8.95	93.0	100.0	10.10	9.30	92.0	100.0	10.10	9.20
3	High	13	132.5*	175.5	19.48	10.19	174.0	175.5	19.31	13.38	167.0	175.5	19.31	12.85
	Low	13	218.5	175.5	19.48	16.81	177.0	175.5	19.31	13.62	184.0	175.5	19.31	14.15
4	High	10	118.5	105.0	13.11	11.85	99.0	105.0	12.62	9.90	105.0	105.0	12.62	10.50
	Low	10	91.5	105.0	13.11	9.15	111.0	105.0	12.62	11.10	105.0	105.0	12.62	10.50
5	High	13	169.0	175.5	19.45	13.00	178.0	175.5	19.43	13.69	186.0	175.5	19.43	14.31
	Low	13	182.0	175.5	19.45	14.00	173.0	175.5	19.43	13.31	165.0	175.5	19.43	12.69

		Test 2												
		CONLAT				CONTOATT				ATTILAT				
Replicate	Trait ¹ : Group	N ²	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score
Overall ³	High	59	3650.5	3510.5	185.18	61.87	3443.0	3510.5	183.13	58.36	3441.5	3510.5	183.13	58.33
	Low	60	3370.5	3510.5	185.18	57.13	3578.0	3510.5	183.13	60.64	3579.5	3510.5	183.13	60.67
1	High	14	211.5	196.0	20.46	15.11	186.5	196.0	20.43	13.32	187.0	196.0	20.42	13.36
	Low	14	166.5	182.0	20.46	12.81	191.5	182.0	20.43	14.73	191.0	182.0	20.42	14.69
2	High	9	78.5	90.0	12.13	8.72	105.0	90.0	12.19	11.67	104.0	90.0	12.19	11.56
	Low	10	111.5	100.0	12.13	11.15	85.0	100.0	12.19	8.50	86.0	100.0	12.19	8.60
3	High	13	165.5	175.5	19.44	12.73	162.0	175.5	18.75	12.46	152.5	175.5	18.75	11.73
	Low	13	185.5	175.5	19.44	14.27	189.0	175.5	18.75	14.54	198.5	175.5	18.75	15.27
4	High	10	109.0	105.0	13.21	10.90	87.5†	105.0	12.94	8.75	85.5†	105.0	12.94	8.55
	Low	10	101.0	105.0	13.21	10.10	122.5	105.0	12.94	12.25	124.5	105.0	12.94	12.45
5	High	13	211.5*	175.5	19.43	16.27	198.0	175.5	19.30	15.23	206.0†	175.5	19.31	15.85
	Low	13	139.5	175.5	19.43	10.73	153.0	175.5	19.30	11.77	145.0	175.5	19.31	11.15

		OVERALL												
		TCONLAT				TCONTOATT				TATILAT				
Replicate	Trait ¹ : Group	N ²	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score
Overall ³	High	59	3476.0	3510.5	185.73	58.92	3514.5	3510.5	185.79	59.57	3472.5	3510.5	185.45	58.86
	Low	60	3545.0	3510.5	185.73	60.08	3506.5	3510.5	185.79	59.43	3548.5	3510.5	185.45	60.14
1	High	14	188.5	196.0	20.58	13.46	193.5	196.0	20.60	13.82	188.0	196.0	20.57	13.43
	Low	14	189.5	182.0	20.58	14.58	184.5	182.0	20.60	14.19	190.0	182.0	20.57	14.62
2	High	9	95.5	90.0	12.24	10.61	104.0	90.0	12.25	11.56	102.0	90.0	12.19	11.33
	Low	10	94.5	100.0	12.24	9.45	86.0	100.0	12.25	8.60	88.0	100.0	12.19	8.80
3	High	13	143.5†	175.5	19.49	11.04	173.5	175.5	19.50	13.35	160.5	175.5	19.46	12.35
	Low	13	207.5	175.5	19.49	15.96	177.5	175.5	19.50	13.65	190.5	175.5	19.46	14.65
4	High	10	114.0	105.0	13.22	11.40	89.0	105.0	13.23	8.90	90.0	105.0	13.17	9.00
	Low	10	96.0	105.0	13.22	9.60	121.0	105.0	13.23	12.10	120.0	105.0	13.17	12.00
5	High	13	199.5	175.5	19.47	15.35	194.0	175.5	19.50	14.92	202.5†	175.5	19.49	15.58
	Low	13	151.5	175.5	19.47	11.65	157.0	175.5	19.50	12.08	148.5	175.5	19.49	11.42

¹Latency to Contact = time between intruder introduction and first contact by resident pig, Time Contact to Attack = time from first contact by resident until attack occurrence, Latency to Attack = time from intruder introduction until attack occurrence, Total Latency to Contact = sum of time between intruder introduction and first contact by resident pig from tests 1 and 2, Total Time Contact to Attack = sum of time from first contact by resident until attack occurrence from tests 1 and 2, Total Latency to Attack = sum of time from intruder introduction until attack occurrence from tests 1 and 2

²N = number of pigs included in analysis

³Overall LSMeans have also been adjusted for replicate

†Indicates difference between High and Low pigs at P ≤ 0.1

*Indicates significant difference between High and Low pigs at P ≤ 0.05

Table 13. Resident Intruder Attack Score¹ Frequency² and Chi-Squared Values

Replicate	Group	Test 1			Test 2			Overall ³			
		Score Frequencies		Chi-Squared Value	Score Frequencies		Chi-Squared Value	Score Frequencies			Chi-Squared Value
		1	0		1	0		2	1	0	
Overall	High	62.71	37.29	0.32	71.19	28.81	0.16	47.46	38.98	13.56	0.41
	Low	57.63	42.37		67.80	32.20		42.37	40.68	16.95	
1	High	57.14	42.86	0.14	78.57	21.43	0.31	50.00	35.71	14.29	1.12
	Low	50.00	50.00		69.23	30.77		30.77	53.85	15.38	
2	High	22.22	77.78	0.69	77.78	22.22	0.01	22.22	55.56	22.22	0.73
	Low	40.00	60.00		80.00	20.00		40.00	40.00	20.00	
3	High	83.33	16.67	0.68	75.00	25.00	2.16	66.67	25.00	8.33	3.23
	Low	69.23	30.77		46.15	53.85		30.77	53.85	15.38	
4	High	60.00	40.00	0.20	80.00	20.00	1.98	50.00	40.00	10.00	1.50
	Low	50.00	50.00		50.00	50.00		30.00	40.00	30.00	
5	High	84.62	15.38	0.25	53.85	46.15	7.29**	46.15	46.15	7.69	3.97
	Low	76.92	23.08		100.00	0.00		83.33	16.67	0.00	

¹Attack Score = Whether or not attack occurred during test; 1 = attack occurred, 0 = no attack occurred

²Frequency = percentage of pigs in group with specified attack score

³Overall Attack Score: 2 = attack occurred during both test 1 and test 2, 1 = attack occurred during test 1 or test 2, 0 = no attack occurred during either test

**Indicates significant difference between High and Low pigs at $P \leq 0.01$

Table 14a. Maze Trials, 10 Minute Maximum, LSMeans¹, All Selected Pigs

		Maze 1						Maze 2					
Trait ² :		Time ^b			Errors ^a			Time ^a			Errors ^a		
		95% Confidence Limits			95% Confidence Limits			95% Confidence Limits			95% Confidence Limits		
Replicate	Group	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper
Overall ³	High	125.53	114.20	137.39	4.31	3.90	4.76	73.17	63.41	84.44	3.86	3.41	4.39
	Low	133.23	122.10	144.85	5.47	4.91	6.09	67.55	58.73	77.68	3.70	3.29	4.17
1	High	170.16	144.25	198.22	3.40	2.79	4.14	132.11	99.49	175.41	5.49†	4.39	6.85
	Low	116.51	95.31	139.84	4.20	3.34	5.27	78.51	58.59	105.20	3.15	2.53	3.93
2	High	142.87	111.07	178.66	3.66	2.80	4.78	92.85	65.02	132.60	5.12	3.67	7.14
	Low	110.18	86.72	136.45	5.21	3.99	6.81	62.65	44.76	87.67	4.36	3.23	5.89
3	High	67.30*	51.44	85.29	9.19	7.49	11.26	53.52	39.94	71.72	3.03	2.34	3.93
	Low	128.02	105.75	152.43	6.56	5.35	8.04	53.92	40.24	72.25	4.36	3.36	5.66
4	High	97.43**	75.45	122.21	3.65	2.90	4.58	67.23	47.22	95.72	3.31	2.44	4.50
	Low	211.83	178.99	247.43	5.19	4.13	6.52	117.74	84.34	164.37	3.87	2.98	5.02
5	High	167.63	141.99	195.40	3.56†	2.93	4.32	47.52	35.46	63.68	3.05	2.31	4.04
	Low	111.37	90.32	134.61	6.57	5.14	8.39	45.03	33.43	60.65	3.00	2.27	3.96
		Maze 3						Maze 4					
Trait ² :		Time ^a			Errors ^a			Time ^a			Errors ^a		
		95% Confidence Limits			95% Confidence Limits			95% Confidence Limits			95% Confidence Limits		
Replicate	Group	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper
Overall ³	High	123.51	105.33	144.82	5.39†	4.71	6.16	92.47	78.11	109.48	4.39	3.89	4.94
	Low	94.83	81.18	110.77	3.79	3.32	4.32	113.97	96.65	134.38	4.33	3.84	4.88
1	High	191.96†	140.08	263.06	5.42	4.27	6.89	77.68	55.61	108.51	3.50	2.75	4.47
	Low	86.44	62.43	119.68	3.36	2.44	4.62	161.10	114.15	227.63	4.50	3.56	5.68
2	High	176.80	118.99	262.70	7.08	5.14	9.76	100.79	66.23	153.38	4.42	3.28	5.96
	Low	94.64	65.14	137.51	3.53	2.66	4.70	227.03	152.76	337.41	5.90	4.54	7.66
3	High	48.69	35.16	67.41	5.51	3.71	8.17	38.31†	27.13	54.10	2.86	2.18	3.76
	Low	71.43	51.59	98.90	3.66	2.82	4.76	86.80	61.47	122.57	4.44	3.38	5.82
4	High	179.58	121.24	265.97	5.10	3.92	6.63	166.07	109.50	251.87	6.61	5.03	8.68
	Low	196.29	135.46	284.43	5.89	4.54	7.65	138.84	93.69	205.74	5.52	4.20	7.24
5	High	96.82	69.93	134.06	4.20	3.38	5.22	135.78*	96.15	191.73	5.53*	4.43	6.92
	Low	66.88	48.03	93.12	3.04	2.25	4.12	43.58	30.68	61.91	2.34	1.74	3.14
		Maze 5						Maze 6					
Trait ² :		Time			Errors ^a			Time			Errors ^a		
		95% Confidence Limits			95% Confidence Limits			95% Confidence Limits			95% Confidence Limits		
Replicate	Group	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper
Overall ³	High	316.92	283.73	350.11	6.65	5.95	7.43	374.96	342.37	407.55	7.08	6.32	7.94
	Low	321.44	289.03	353.85	6.93	6.17	7.79	352.97	321.15	384.79	6.24	5.54	7.03
1	High	233.09	167.38	298.80	4.10	3.26	5.14	321.39	256.88	385.90	6.56	5.13	8.39
	Low	321.62	253.77	389.47	5.29	4.06	6.89	246.09	179.47	312.71	4.62	3.51	6.08
2	High	338.47	255.89	421.05	7.54	5.75	9.88	377.28	296.21	458.35	8.16	6.16	10.81
	Low	384.28	306.36	462.20	6.58	5.05	8.56	367.06	290.56	443.56	6.56	4.90	8.80
3	High	271.00	203.15	338.85	6.08	4.81	7.70	381.62	315.00	448.24	4.47†	3.57	5.59
	Low	352.07	284.22	419.92	8.71	6.88	11.03	447.53	380.91	514.15	7.76	6.20	9.71
4	High	410.91	329.01	492.81	8.48	6.51	11.05	382.37	301.96	462.78	8.39	6.26	11.24
	Low	298.20	220.86	375.54	7.23	5.46	9.59	371.60	295.67	447.53	4.81	3.59	6.45
5	High	331.15	263.30	399.00	8.18	6.54	10.25	412.15	345.53	478.77	8.87	7.15	11.00
	Low	251.05	182.03	320.07	7.30	5.65	9.45	332.56	264.80	400.32	8.37	6.59	10.63

¹LSMeans have been adjusted for sex

²Time = time for pig to complete the maze trial, Errors = number of errors during the maze trial

³Overall LSMeans have also been adjusted for replicate

^aData were log transformed for analysis and backtransformed to display in this table

^bData were square root transformed for analysis and backtransformed to display in this table

†Indicates difference between High and Low pigs at P ≤ 0.1

*Indicates significant difference between High and Low pigs at P ≤ 0.05

**Indicates significant difference between High and Low pigs at P ≤ 0.01

Table 14b. Maze Trials Differences, 10 Minute Maximum, LSMeans¹, All Selected Pigs

Comparisons ² :		Maze 1 vs Maze 2				Maze 2 vs Maze 3			
Trait ³ :		Time Difference		Error Difference		Time Difference		Error Difference	
Replicate	Group	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error
<i>Overall</i> ⁴	High	-42.38	27.03	-1.16	0.91	84.88	32.95	1.46	0.90
	Low	-28.99	26.39	-1.19	0.89	64.40	32.17	0.98	0.88
1	High	73.60	53.51	3.49	1.79	36.67	65.23	-1.24	1.78
	Low	-27.42	55.26	0.54	1.85	57.60	67.36	-1.28	1.84
2	High	51.22	67.25	0.65	2.25	81.69	81.97	1.56	2.24
	Low	-45.74	63.45	-0.19	2.13	72.66	77.34	0.94	2.11
3	High	-144.34	55.26	-6.46	1.85	51.68	67.36	-0.20	1.84
	Low	-108.58	55.26	-3.38	1.85	67.40	67.36	0.51	1.84
4	High	-111.47†	66.70	-1.01	2.24	161.95	81.30	3.80	2.22
	Low	49.50	62.98	-1.30	2.11	123.70	76.77	4.90	2.09
5	High	-80.89	55.26	-2.46	1.85	92.40	67.36	3.35	1.84
	Low	-12.71	56.21	-1.60	1.88	0.62	68.51	-0.14	1.87
Comparisons ² :		Maze 3 vs Maze 4				Maze 4 vs Maze 5			
Trait ³ :		Time Difference		Error Difference		Time Difference		Error Difference	
Replicate	Group	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error
<i>Overall</i> ⁴	High	-24.69	30.59	-0.02	0.82	126.65	34.51	2.18	0.94
	Low	44.35	29.87	0.43	0.80	84.27	33.70	1.87	0.92
1	High	-78.70*	60.57	-1.60†	1.62	59.26	68.33	0.38	1.86
	Low	101.89	62.54	2.46	1.67	33.05	70.56	-0.55	1.92
2	High	-77.35**	76.11	-1.05	2.03	142.37	85.87	2.91	2.33
	Low	196.57	71.82	2.63	1.92	1.83	81.02	-0.43	2.20
3	High	-51.80	62.54	-0.24	1.67	202.28	70.56	4.06	1.92
	Low	5.19	62.54	0.24	1.67	190.87	70.56	5.01	1.92
4	High	44.85	75.49	1.53	2.02	103.78	85.17	1.06	2.31
	Low	-37.20	71.28	-2.60	1.90	16.20	80.42	0.40	2.18
5	High	39.57	62.54	1.24	1.67	125.56	70.56	2.47	1.92
	Low	-44.69	63.62	-0.57	1.70	179.41	71.77	4.94	1.95
Comparisons ² :		Maze 5 vs Maze 6							
Trait ³ :		Time Difference		Error Difference					
Replicate	Group	Mean	Standard Error	Mean	Standard Error				
<i>Overall</i> ⁴	High	57.98	35.43	1.32	1.03				
	Low	31.51	34.59	-0.31	1.01				
1	High	88.15	70.14	1.13	2.04				
	Low	-75.38	72.43	-0.43	2.11				
2	High	38.90	88.15	0.80	2.57				
	Low	-17.21	83.17	-1.28	2.42				
3	High	110.54	72.43	-0.20	2.11				
	Low	95.15	72.43	0.20	2.11				
4	High	-28.55	87.43	2.04	2.55				
	Low	73.40	82.55	-2.40	2.41				
5	High	80.84	72.43	2.81	2.11				
	Low	81.60	73.67	2.38	2.15				

¹LSMeans have been adjusted for sex²Comparisons: Maze X vs Maze Y = (maze trial Y) - (maze trial X)³Time Difference = change in time to complete maze trials, Error Difference = change in errors during maze trials⁴Overall LSMeans have also been adjusted for replicate

†Indicates difference between High and Low pigs at P ≤ 0.1

*Indicates significant difference between High and Low pigs at P ≤ 0.05

**Indicates significant difference between High and Low pigs at P ≤ 0.01

Table 14c. Maze Trials, 10 Minute Maximum, LSMMeans¹, Only Pigs that Completed Maze Trials Within Time Limit

		Maze 1						Maze 2					
Trait ² :		Time ^b			Errors ^a			Time ^a			Errors ^a		
		95% Confidence Limits			95% Confidence Limits			95% Confidence Limits			95% Confidence Limits		
Replicate	Group	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper
Overall ³	High	121.85	110.81	133.41	4.18	3.78	4.62	63.25	55.36	72.26	3.24	2.86	3.68
	Low	133.62	122.63	145.09	5.35	4.80	5.96	57.40	50.41	65.36	3.44	3.07	3.86
1	High	170.69	145.36	198.04	3.42	2.82	4.15	103.38	78.69	135.82	4.27	3.41	5.34
	Low	107.99	87.32	130.85	3.76	2.96	4.78	65.84	50.18	86.38	3.12	2.53	3.86
2	High	143.76	112.62	178.69	3.69	2.84	4.81	56.87	39.79	81.28	2.71	1.84	3.99
	Low	109.45	86.63	134.94	5.16	3.96	6.72	62.11	46.04	83.78	4.36	3.32	5.73
3	High	67.41**	51.92	84.93	9.21	7.54	11.27	53.60	41.31	69.55	3.03	2.40	3.84
	Low	141.22	117.46	167.16	6.66	5.39	8.24	53.83	41.48	69.85	4.31	3.40	5.47
4	High	86.48**	65.39	110.52	3.46	2.72	4.39	67.71	49.44	92.75	3.42	2.59	4.51
	Low	211.83	179.80	246.48	5.17	4.13	6.48	78.34	56.20	109.18	3.31	2.52	4.35
5	High	159.47	134.11	187.01	3.16*	2.59	3.86	47.44	36.56	61.56	2.99	2.32	3.86
	Low	110.38	89.93	132.93	6.53	5.12	8.31	36.13	27.35	47.72	2.49	1.89	3.27
		Maze 3						Maze 4					
Trait ² :		Time ^a			Errors ^a			Time ^a			Errors ^a		
		95% Confidence Limits			95% Confidence Limits			95% Confidence Limits			95% Confidence Limits		
Replicate	Group	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper
Overall ³	High	102.75*	88.79	118.90	4.7**	4.17	5.49	71.61	60.89	84.22	4.12	3.63	4.68
	Low	63.19	54.30	73.55	2.95	2.55	3.42	64.80	54.13	77.57	3.13	2.71	3.62
1	High	176.55**	133.42	233.62	4.78†	3.80	6.01	55.87	40.50	77.08	2.90	2.23	3.78
	Low	48.99	35.62	67.40	2.05	1.35	3.10	71.31	48.41	105.05	3.12	2.36	4.12
2	High	124.45	84.85	182.53	6.62*	4.63	9.46	62.60	41.24	95.00	3.85	2.76	5.37
	Low	58.47	40.80	83.78	2.28	1.68	3.10	82.72	50.42	135.72	3.72	2.54	5.44
3	High	39.28	29.38	52.52	4.07	2.70	6.16	38.43†	28.36	52.08	2.93	2.26	3.80
	Low	71.21	53.87	94.15	3.64	2.87	4.62	86.52	63.85	117.25	4.44	3.42	5.75
4	High	158.70	110.75	227.40	4.62	3.57	5.97	117.06	77.13	177.67	7.06*	5.22	9.54
	Low	89.97	59.57	135.88	4.15	3.00	5.74	52.53	33.53	82.29	2.61	1.80	3.77
5	High	83.60	62.52	111.78	4.23	3.44	5.20	119.67*	87.17	164.27	5.14*	4.12	6.42
	Low	54.92	40.88	73.77	3.17	2.35	4.27	42.62	31.24	58.14	2.25	1.70	2.98
		Maze 5						Maze 6					
Trait ² :		Time			Errors ^a			Time			Errors ^a		
		95% Confidence Limits			95% Confidence Limits			95% Confidence Limits			95% Confidence Limits		
Replicate	Group	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper
Overall ³	High	186.09	157.25	214.93	5.68	4.89	6.59	229.92	196.37	263.47	6.61	5.58	7.84
	Low	170.80	142.34	199.26	5.07	4.28	5.99	210.52	177.10	243.94	5.43	4.52	6.54
1	High	137.62	86.39	188.85	2.90	2.21	3.82	151.20	84.09	218.31	5.01	3.40	7.37
	Low	149.63	89.91	209.35	2.40	1.55	3.71	131.73	70.21	193.25	3.45	2.39	4.99
2	High	143.36	66.84	219.88	8.11	5.46	12.05	260.28	181.55	339.01	7.36	5.08	10.64
	Low	156.84	80.32	233.36	5.39	3.48	8.34	143.70	56.54	230.86	4.69	2.66	8.28
3	High	174.10	120.68	227.52	5.96	4.48	7.93	291.06	226.58	355.54	4.25	3.19	5.65
	Low	240.23	183.88	296.58	7.40	5.57	9.84	205.63	119.77	291.49	7.30	4.85	10.97
4	High	265.36	188.84	341.88	6.25	4.27	9.15	188.43	98.74	278.12	11.73	7.22	19.05
	Low	169.87	105.96	233.78	6.88	4.72	10.03	276.17	203.64	348.70	5.09	3.41	7.61
5	High	210.01	153.66	266.36	6.71	5.04	8.92	258.64	185.33	331.95	6.90	5.06	9.40
	Low	137.44	82.64	192.24	5.07	3.64	7.06	295.38	235.20	355.56	7.89	5.90	10.53

¹LSMeans have been adjusted for sex

²Time = time for pig to complete the maze trial, Errors = number of errors during the maze trial

³Overall LSMMeans have also been adjusted for replicate

^aData were log transformed for analysis and backtransformed to display in this table

^bData were square root transformed for analysis and backtransformed to display in this table

†Indicates difference between High and Low pigs at P ≤ 0.1

*Indicates significant difference between High and Low pigs at P ≤ 0.05

**Indicates significant difference between High and Low pigs at P ≤ 0.01

Table 14d. Maze Trials Differences, 10 Minute Maximum, LSMeans¹, Only Pigs that Completed Maze Trials Within Time Limit

Comparisons ² :		Maze 1 vs Maze 2				Maze 2 vs Maze 3			
Trait ³ :		Time Difference		Error Difference		Time Difference		Error Difference	
Replicate	Group	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error
<i>Overall</i> ⁴	High	-62.36	22.79	-1.87	0.91	69.47	24.11	1.64	0.73
	Low	-48.84	22.10	-1.42	0.88	7.01	24.62	0.08	0.75
1	High	32.35	45.92	1.67	1.83	50.82	48.64	-0.46	1.48
	Low	-16.38	47.83	1.07	1.91	-41.66	53.83	-2.89	1.63
2	High	-50.45	60.11	-1.74	2.40	112.45†	65.80	3.78†	2.00
	Low	-51.22	50.37	-0.31	2.01	-41.93	57.43	-0.91	1.74
3	High	-143.29	43.83	-6.44	1.75	17.08	46.34	-1.00	1.41
	Low	-77.00	45.60	-3.50	1.82	67.59	44.55	0.51	1.35
4	High	-97.43	55.99	-1.06	2.24	113.05	57.43	2.54	1.74
	Low	-38.00	55.84	-2.13	2.23	51.38	65.80	3.06	2.00
5	High	-52.97	45.68	-1.79	1.82	53.92	46.34	3.33	1.41
	Low	-61.61	46.88	-2.26	1.87	-0.32	49.67	0.61	1.51
Comparisons ² :		Maze 3 vs Maze 4				Maze 4 vs Maze 5			
Trait ³ :		Time Difference		Error Difference		Time Difference		Error Difference	
Replicate	Group	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error
<i>Overall</i> ⁴	High	-19.23	22.42	0.34	0.73	53.72	29.92	2.31	1.17
	Low	15.81	26.28	0.56	0.86	85.61	32.18	2.18	1.26
1	High	-108.34*	45.41	-1.86†	1.49	1.91	53.83	-0.84	2.11
	Low	55.61	56.17	2.56	1.84	-10.50	84.02	-2.00	3.29
2	High	-93.89†	56.58	-1.32	1.85	66.21	76.25	4.44	2.99
	Low	56.44	67.16	1.65	2.20	112.49	84.70	2.30	3.32
3	High	-8.42	42.86	0.75	1.40	103.00	53.14	3.60	2.08
	Low	4.67	41.20	0.24	1.35	125.55	56.06	4.29	2.20
4	High	53.26	56.58	3.11	1.85	24.26	84.70	1.95	3.32
	Low	-31.38	74.71	-1.21	2.45	131.83	68.97	3.87	2.70
5	High	61.25	44.79	1.01	1.47	73.22	56.06	2.40	2.20
	Low	-6.30	43.68	-0.46	1.43	68.69	54.68	2.46	2.14
Comparisons ² :		Maze 5 vs Maze 6							
Trait ³ :		Time Difference		Error Difference					
Replicate	Group	Mean	Standard Error	Mean	Standard Error				
<i>Overall</i> ⁴	High	80.16	39.84	2.03	1.43				
	Low	79.49	37.47	1.67	1.34				
1	High	85.47	76.72	0.99	2.75				
	Low	-19.39	73.72	0.28	2.65				
2	High	213.38	98.53	3.00	3.54				
	Low	71.87	98.53	1.01	3.54				
3	High	39.89	74.73	-2.00	2.68				
	Low	102.15	87.28	3.80	3.13				
4	High	-22.49	101.98	4.74	3.66				
	Low	52.00	79.49	-2.50	2.85				
5	High	84.55	87.28	3.40	3.13				
	Low	190.80	72.51	5.76	2.60				

¹LSMeans have been adjusted for sex

²Comparisons: Maze X vs Maze Y = (maze trial Y) - (maze trial X)

³Time Difference = change in time to complete maze trials, Error Difference = change in errors during maze trials

⁴Overall LSMeans have also been adjusted for replicate

†Indicates difference between High and Low pigs at P ≤ 0.1

*Indicates significant difference between High and Low pigs at P ≤ 0.05

Table 15a. Wilcoxon Rank-Sum Analysis of Maze Trial Traits, 10 Minute Maximum

		Maze 1								Maze 2								
Replicate	Group	N ²	Time				Errors				Time				Errors			
			Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score
Overall	High	58	3610.0	3422.0	183.42	62.24	3517.0	3422.0	180.51	60.64	3579.0	3422.0	183.39	61.71	3391.0	3422.0	179.06	58.47
	Low	59	3293.0	3481.0	183.42	55.81	3386.0	3481.0	180.51	57.39	3324.0	3481.0	183.39	56.34	3512.0	3481.0	179.06	59.53
1	High	14	204.0	196.0	20.60	14.57	207.5	196.0	19.95	14.82	226.0†	196.0	20.59	16.14	210.0	196.0	20.38	15.00
	Low	13	174.0	182.0	20.60	13.38	170.5	182.0	19.95	13.12	152.0	182.0	20.59	11.69	168.0	182.0	20.38	12.92
2	High	9	88.0	90.0	12.23	9.78	91.5	90.0	11.92	10.17	100.0	90.0	12.23	11.11	90.5	90.0	11.76	10.06
	Low	10	102.0	100.0	12.23	10.20	98.5	100.0	11.92	9.85	90.0	100.0	12.23	9.00	99.5	100.0	11.76	9.95
3	High	13	185.0	175.5	19.50	14.23	190.0	175.5	19.36	14.62	178.5	175.5	19.49	13.73	167.0	175.5	18.83	12.85
	Low	13	166.0	175.5	19.50	12.77	161.0	175.5	19.36	12.38	172.5	175.5	19.49	13.27	184.0	175.5	18.83	14.15
4	High	9	101.0	90.0	12.25	11.22	81.0	90.0	12.08	9.00	76.0	90.0	12.22	8.44	81.5	90.0	12.01	9.06
	Low	10	89.0	100.0	12.25	8.90	109.0	100.0	12.08	10.90	114.0	100.0	12.22	11.40	108.5	100.0	12.01	10.85
5	High	13	195.5	175.5	19.50	15.04	182.5	175.5	19.09	14.04	189.0	175.5	19.48	14.54	177.0	175.5	18.40	13.62
	Low	13	155.5	175.5	19.50	11.96	168.5	175.5	19.09	12.96	162.0	175.5	19.48	12.46	174.0	175.5	18.40	13.38
		Maze 3								Maze 4								
Replicate	Group	N ²	Time				Errors				Time				Errors			
			Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score
Overall	High	58	3600.5	3422.0	183.20	62.08	3761.0*	3422.0	180.33	64.84	3261.0	3422.0	182.90	56.22	3437.0	3422.0	181.50	59.26
	Low	59	3302.5	3481.0	183.20	55.97	3142.0	3481.0	180.33	53.25	3642.0	3481.0	182.90	61.73	3466.0	3481.0	181.50	58.75
1	High	14	232.0*	196.0	20.57	16.57	239.0*	196.0	20.01	17.07	168.0†	196.0	20.43	12.00	171.0	196.0	20.42	12.21
	Low	13	146.0	182.0	20.57	11.23	139.0	182.0	20.01	10.69	210.0	182.0	20.43	16.15	207.0	182.0	20.42	15.92
2	High	9	102.0	90.0	12.19	11.33	93.5	90.0	12.07	10.39	75.0	90.0	11.94	8.33	74.5	90.0	12.18	8.28
	Low	10	88.0	100.0	12.19	8.80	96.5	100.0	12.07	9.65	115.0	100.0	11.94	11.50	115.5	100.0	12.18	11.55
3	High	13	162.0	175.5	19.50	12.46	148.0†	175.5	18.12	11.38	143.5†	175.5	19.49	11.04	162.0	175.5	18.85	12.46
	Low	13	189.0	175.5	19.50	14.54	203.0	175.5	18.12	15.62	207.5	175.5	19.49	15.96	189.0	175.5	18.85	14.54
4	High	9	86.0	90.0	12.14	9.56	88.5	90.0	12.17	9.83	89.0	90.0	12.05	9.89	98.5	90.0	12.18	10.94
	Low	10	104.0	100.0	12.14	10.40	101.5	100.0	12.17	10.15	101.0	100.0	12.05	10.10	91.5	100.0	12.18	9.15
5	High	13	194.5	175.5	19.49	14.96	234.5**	175.5	19.24	18.04	222.5**	175.5	19.49	17.12	230.0**	175.5	19.26	17.69
	Low	13	156.5	175.5	19.49	12.04	116.5	175.5	19.24	8.96	128.5	175.5	19.49	9.88	121.0	175.5	19.26	9.31
		Maze 5								Maze 6								
Replicate	Group	N ²	Time				Errors				Time				Errors			
			Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score
Overall	High	58	3427.5	3422.0	180.27	59.09	3541.5	3422.0	182.08	61.06	3506.0	3422.0	178.83	60.45	3651.0	3422.0	182.57	62.95
	Low	59	3475.5	3481.0	180.27	58.91	3361.5	3481.0	182.08	56.97	3397.0	3481.0	178.83	57.58	3252.0	3481.0	182.57	55.12
1	High	14	187.5	196.0	20.34	13.39	201.5	196.0	20.26	14.39	209.5	196.0	20.34	14.96	217.5	196.0	20.09	15.54
	Low	13	190.5	182.0	20.34	14.65	176.5	182.0	20.26	13.58	168.5	182.0	20.34	12.96	160.5	182.0	20.09	12.35
2	High	9	87.0	90.0	11.58	9.67	97.5	90.0	12.17	10.83	89.5	90.0	11.79	9.94	106.0	90.0	12.14	11.78
	Low	10	103.0	100.0	11.58	10.30	92.5	100.0	12.17	9.25	100.5	100.0	11.79	10.05	84.0	100.0	12.14	8.40
3	High	13	162.0	175.5	19.31	12.46	160.5	175.5	19.35	12.35	153.0	175.5	18.52	11.77	146.5†	175.5	19.45	11.27
	Low	13	189.0	175.5	19.31	14.54	190.5	175.5	19.35	14.65	198.0	175.5	18.52	15.23	204.5	175.5	19.45	15.73
4	High	9	98.0	90.0	11.94	10.89	102.0	90.0	12.18	11.33	92.0	90.0	11.94	10.22	100.0	90.0	12.09	11.11
	Low	10	92.0	100.0	11.94	9.20	88.0	100.0	12.18	8.80	98.0	100.0	11.94	9.80	90.0	100.0	12.09	9.00
5	High	13	194.0	175.5	19.31	14.92	192.5	175.5	19.35	14.81	198.0	175.5	19.22	15.23	189.5	175.5	19.41	14.58
	Low	13	157.0	175.5	19.31	12.08	158.5	175.5	19.35	12.19	153.0	175.5	19.22	11.77	161.5	175.5	19.41	12.42

¹Time = time for pig to complete the maze trial, Errors = number of errors during the maze trial

²N = number of pigs included in analysis

Table 15b. Wilcoxon Rank-Sum Analysis of Maze Trial Trait Comparisons, 10 Minute Maximum

		Maze 1 vs Maze 2								Maze 2 vs Maze 3								
		Time				Errors				Time				Errors				
Replicate	Group	N ³	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score
Overall	High	58	3407.5	3422.0	183.43	58.75	3435.0	3422.0	182.73	59.22	3542.0	3422.0	183.43	61.07	3655.0†	3422.0	182.55	63.02
	Low	59	3495.5	3481.0	183.43	59.25	3468.0	3481.0	182.73	58.78	3361.0	3481.0	183.43	56.97	3248.0	3481.0	182.55	55.05
1	High	14	217.0	196.0	20.60	15.50	207.5	196.0	20.45	14.82	204.0	196.0	20.61	14.57	205.5	196.0	20.53	14.68
	Low	13	161.0	182.0	20.60	12.38	170.5	182.0	20.45	13.12	174.0	182.0	20.61	13.38	172.5	182.0	20.53	13.27
2	High	9	104.0	90.0	12.25	11.56	94.0	90.0	12.23	10.44	94.0	90.0	12.25	10.44	92.0	90.0	12.22	10.22
	Low	10	86.0	100.0	12.25	8.60	96.0	100.0	12.23	9.60	96.0	100.0	12.25	9.60	98.0	100.0	12.22	9.80
3	High	13	178.5	175.5	19.50	13.73	162.0	175.5	19.44	12.46	167.0	175.5	19.49	12.85	159.5	175.5	19.06	12.27
	Low	13	172.5	175.5	19.50	13.27	189.0	175.5	19.44	14.54	184.0	175.5	19.49	14.15	191.5	175.5	19.06	14.73
4	High	9	67.0*	90.0	12.25	7.44	88.5	90.0	11.92	9.83	95.0	90.0	12.24	10.56	93.0	90.0	12.22	10.33
	Low	10	123.0	100.0	12.25	12.30	101.5	100.0	11.92	10.15	95.0	100.0	12.24	9.50	97.0	100.0	12.22	9.70
5	High	13	164.0	175.5	19.50	12.62	174.0	175.5	19.41	13.38	198.0	175.5	19.50	15.23	217.5*	175.5	19.26	16.73
	Low	13	187.0	175.5	19.50	14.38	177.0	175.5	19.41	13.62	153.0	175.5	19.50	11.77	133.5	175.5	19.26	10.27
		Maze 3 vs Maze 4								Maze 4 vs Maze 5								
		Time				Errors				Time				Errors				
Replicate	Group	N ³	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score
Overall	High	58	3126.5*	3422.0	183.39	53.91	3303.0	3422.0	182.46	56.95	3544.5	3422.0	183.28	61.11	3531.5	3422.0	182.91	60.89
	Low	59	3776.5	3481.0	183.39	64.01	3600.0	3481.0	182.46	61.02	3358.5	3481.0	183.28	56.92	3371.5	3481.0	182.91	57.14
1	High	14	153.5*	196.0	20.60	10.96	161.0*	196.0	20.57	11.50	205.5	196.0	20.60	14.68	210.0	196.0	20.47	15.00
	Low	13	224.5	182.0	20.60	17.27	217.0	182.0	20.57	16.69	172.5	182.0	20.60	13.27	168.0	182.0	20.47	12.92
2	High	9	69.0†	90.0	12.19	7.67	78.0	90.0	12.12	8.67	104.0	90.0	12.06	11.56	106.5†	90.0	12.23	11.83
	Low	10	121.0	100.0	12.19	12.10	112.0	100.0	12.12	11.20	86.0	100.0	12.06	8.60	83.5	100.0	12.23	8.35
3	High	13	158.0	175.5	19.50	12.15	187.0	175.5	19.26	14.38	184.0	175.5	19.50	14.15	173.0	175.5	19.37	13.31
	Low	13	193.0	175.5	19.50	14.85	164.0	175.5	19.26	12.62	167.0	175.5	19.50	12.85	178.0	175.5	19.37	13.69
4	High	9	98.0	90.0	12.23	10.89	102.0	90.0	12.19	11.33	95.5	90.0	12.19	10.61	95.0	90.0	12.22	10.56
	Low	10	92.0	100.0	12.23	9.20	88.0	100.0	12.19	8.80	94.5	100.0	12.19	9.45	95.0	100.0	12.22	9.50
5	High	13	199.0	175.5	19.50	15.31	188.5	175.5	19.39	14.50	163.5	175.5	19.50	12.58	155.0	175.5	19.44	11.92
	Low	13	152.0	175.5	19.50	11.69	162.5	175.5	19.39	12.50	187.5	175.5	19.50	14.42	196.0	175.5	19.44	15.08
		Maze 5 vs Maze 6																
		Time				Errors												
Replicate	Group	N ³	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score
Overall	High	58	3510.0	3422.0	182.91	60.52	3580.0	3422.0	183.00	61.72								
	Low	59	3393.0	3481.0	182.91	57.51	3323.0	3481.0	183.00	56.32								
1	High	14	227.5†	196.0	20.59	16.25	211.5	196.0	20.47	15.11								
	Low	13	150.5	182.0	20.59	11.58	166.5	182.0	20.47	12.81								
2	High	9	98.0	90.0	12.06	10.89	100.0	90.0	12.17	11.11								
	Low	10	92.0	100.0	12.06	9.20	90.0	100.0	12.17	9.00								
3	High	13	174.0	175.5	19.43	13.38	164.0	175.5	19.45	12.62								
	Low	13	177.0	175.5	19.43	13.62	187.0	175.5	19.45	14.38								
4	High	9	77.0	90.0	12.14	8.56	95.5	90.0	12.17	10.61								
	Low	10	113.0	100.0	12.14	11.30	94.5	100.0	12.17	9.45								
5	High	13	174.0	175.5	19.49	13.38	178.0	175.5	19.49	13.69								
	Low	13	177.0	175.5	19.49	13.62	173.0	175.5	19.49	13.31								

¹Comparisons: Maze X vs Maze Y = (errors during maze trial Y) - (errors during maze trial X)

²Time = time for pig to complete the maze trial, Errors = number of errors during the maze trial

³N = number of pigs included in analysis

Table 16. Maze Trials, 10 Minute Maximum, Completion Frequency¹ and Chi-Squared Values

Replicate	Group	Maze 1		Maze 2		Maze 3		Maze 4		Maze 5		Maze 6							
		Completion Frequencies		Chi-Squared Value		Completion Frequencies		Chi-Squared Value		Completion Frequencies		Chi-Squared Value							
		1	0	1	0	1	0	1	0	1	0	1	0						
Overall	High	96.55	3.45	0.00	93.10	6.90	0.00	89.66	10.34	1.08	87.93	12.07	2.70†	68.97	31.03	0.11	62.07	37.93	0.15
	Low	96.61	3.39		93.22	6.78		83.05	16.95		76.27	23.73		66.10	33.90		65.52	34.48	
1	High	100.00	0.00	1.12	85.71	14.29	0.30	92.86	7.14	1.36	85.71	14.29	2.05	78.57	21.43	0.94	64.29	35.71	0.52
	Low	92.31	7.69		92.31	7.69		76.92	23.08		61.54	38.46		61.54	38.46		76.92	23.08	
2	High	100.00	0.00	-	77.78	22.22	2.48	77.78	22.22	0.01	77.78	22.22	1.57	55.56	44.44	0.06	66.67	33.33	0.54
	Low	100.00	0.00		100.00	0.00		80.00	20.00		50.00	50.00		50.00	50.00		50.00	50.00	
3	High	100.00	0.00	0.88	100.00	0.00	-	90.91	9.09	1.23	100.00	0.00	-	90.91	9.09	1.70	81.82	18.18	4.61*
	Low	92.31	7.69		100.00	0.00		100.00	0.00		100.00	0.00		69.23	30.77		38.46	61.54	
4	High	88.89	11.11	1.17	100.00	0.00	2.01	88.89	11.11	2.04	77.78	22.22	0.69	55.56	44.44	0.42	55.56	44.44	0.42
	Low	100.00	0.00		80.00	20.00		60.00	40.00		60.00	40.00		70.00	30.00		70.00	30.00	
5	High	92.31	7.69	0.96	100.00	0.00	-	92.31	7.69	0.96	92.31	7.69	0.96	69.23	30.77	0.68	53.85	46.15	4.43*
	Low	100.00	0.00		100.00	0.00		100.00	0.00		100.00	0.00		83.33	16.67		91.67	8.33	

¹Completion Frequency = percentage of pigs in group that completed maze within allotted time; 1 = completed, 0 = did not complete

†Indicates difference between High and Low pigs at P ≤ 0.1

*Indicates significant difference between High and Low pigs at P ≤ 0.05

Table 17a. Maze Trials, 3 Minute Maximum, LSMeans¹, All Selected Pigs

		Maze 1						Maze 2					
Trait ² :		Time			Errors ^a			Time ^a			Errors ^b		
		95% Confidence Limits			95% Confidence Limits			95% Confidence Limits			95% Confidence Limits		
Replicate	Group	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper
<i>Overall</i> ³	High	125.89	115.02	136.76	4.18†	3.78	4.63	50.73	43.60	59.02	1.03	0.71	1.42
	Low	113.64	102.27	125.01	5.39	4.82	6.02	51.97	44.36	60.89	1.37	0.98	1.83
3	High	141.50	123.70	159.30	7.70	6.50	9.11	52.22	40.75	66.91	1.13	0.60	1.82
	Low	127.75	110.64	144.86	5.99	5.10	7.03	51.01	40.19	64.75	1.70	1.06	2.49
4	High	137.41	116.69	158.13	3.46	2.86	4.19	60.22	45.12	80.37	1.29	0.65	2.16
	Low	125.68	102.34	149.02	4.91	3.99	6.05	68.44	49.45	94.73	1.72	0.88	2.84
5	High	98.75	80.95	116.55	2.75**	2.34	3.22	41.53	32.41	53.21	0.72	0.32	1.29
	Low	87.49	69.87	105.11	5.32	4.38	6.46	40.21	31.46	51.40	0.81	0.38	1.40
		Maze 3						Maze 4					
Trait ² :		Time			Errors ^a			Time			Errors ^a		
		95% Confidence Limits			95% Confidence Limits			95% Confidence Limits			95% Confidence Limits		
Replicate	Group	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper
<i>Overall</i> ³	High	101.29	89.27	113.31	3.61	3.19	4.08	101.17	89.39	112.95	3.55	3.19	3.96
	Low	97.03	84.46	109.61	2.95	2.61	3.34	91.33	79.00	103.65	2.90	2.57	3.28
3	High	68.75	49.07	88.43	3.90	2.97	5.12	58.50†	39.21	77.79	2.99	2.45	3.65
	Low	90.39	71.46	109.31	2.72	2.27	3.26	107.56	89.02	126.10	3.85	3.16	4.69
4	High	140.44	117.53	163.35	4.09	3.38	4.96	122.69	100.24	145.14	3.71	3.04	4.52
	Low	115.86	90.06	141.66	3.25	2.60	4.06	102.04	76.76	127.32	2.93	2.32	3.71
5	High	94.67	74.98	114.35	2.94	2.52	3.43	122.33*	103.04	141.62	4.04*	3.45	4.73
	Low	84.85	65.37	104.34	2.92	2.32	3.66	64.38	45.29	83.47	2.17	1.78	2.65
		Maze 5						Maze 6					
Trait ² :		Time			Errors ^a			Time			Errors ^a		
		95% Confidence Limits			95% Confidence Limits			95% Confidence Limits			95% Confidence Limits		
Replicate	Group	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper
<i>Overall</i> ³	High	134.82	123.00	146.64	4.14	3.65	4.71	154.52	144.39	164.65	3.77	3.34	4.26
	Low	130.88	118.52	143.24	4.37	3.78	5.06	140.72	130.12	151.32	3.65	3.08	4.33
3	High	125.50	106.15	144.85	4.45	3.55	5.58	146.83	130.25	163.41	2.28	1.90	2.74
	Low	144.69	126.09	163.29	4.77	3.90	5.83	156.47	140.53	172.41	3.50	2.91	4.21
4	High	140.03	117.50	162.56	3.64	2.90	4.56	149.74	130.43	169.05	4.45	3.46	5.72
	Low	126.70	101.33	152.07	4.56	3.32	6.26	126.02	104.28	147.76	3.16	2.05	4.87
5	High	138.92	119.57	158.27	4.40	3.56	5.44	167.00	150.42	183.58	5.29	4.40	6.36
	Low	121.26	102.10	140.42	3.84	3.07	4.81	139.68	123.26	156.10	4.41	3.63	5.35

¹LSMeans have been adjusted for sex

²Time = time for pig to complete the maze trial, Errors = number of errors during the maze trial

³Overall LSMeans have also been adjusted for replicate

^aData were log transformed for analysis and backtransformed to display in this table

^bData were square root transformed for analysis and backtransformed to display in this table

†Indicates difference between High and Low pigs at P ≤ 0.1

*Indicates significant difference between High and Low pigs at P ≤ 0.05

**Indicates significant difference between High and Low pigs at P ≤ 0.01

Table 17b. Maze Trials Differences, 3 Minute Maximum, LSMeans¹, All Selected Pigs

Comparisons ² :		Maze 1 vs Maze 2				Maze 2 vs Maze 3			
Trait ³ :		Time Difference		Error Difference		Time Difference		Error Difference	
Replicate	Group	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error
<i>Overall</i> ⁴	High	-58.22	13.68	-2.03	0.81	33.62	13.02	0.98	0.57
	Low	-40.90	14.31	-2.06	0.84	24.30	13.63	0.09	0.59
3	High	-72.75	22.40	-4.33	1.32	0.00	21.33	-0.92	0.93
	Low	-55.67	21.53	-2.77	1.27	18.30	20.51	-0.75	0.89
4	High	-63.67	26.08	-0.68	1.54	66.70	24.83	2.04	1.08
	Low	-50.38	29.36	-1.99	1.73	40.56	27.96	0.89	1.22
5	High	-38.25	22.40	-1.08	1.32	34.17	21.33	1.83	0.93
	Low	-16.66	22.18	-1.44	1.31	14.03	21.12	0.12	0.92
Comparisons ² :		Maze 3 vs Maze 4				Maze 4 vs Maze 5			
Trait ³ :		Time Difference		Error Difference		Time Difference		Error Difference	
Replicate	Group	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error
<i>Overall</i> ⁴	High	-0.11	13.15	0.13	0.58	33.64	14.53	0.72	0.72
	Low	-5.71	13.76	-0.28	0.61	39.56	15.20	1.34	0.76
3	High	-10.25	21.53	0.58	0.96	67.00	23.79	2.00	1.19
	Low	17.17	20.70	0.49	0.92	37.13	22.87	1.81	1.14
4	High	-17.75	25.07	-1.02	1.12	17.34	27.69	0.58	1.38
	Low	-13.82	28.22	-1.09	1.26	24.66	31.18	0.51	1.56
5	High	27.67	21.53	0.83	0.96	16.58	23.79	-0.42	1.19
	Low	-20.47	21.32	-0.25	0.95	56.88	23.55	1.70	1.17
Comparisons ² :		Maze 5 vs Maze 6							
Trait ³ :		Time Difference		Error Difference					
Replicate	Group	Mean	Standard Error	Mean	Standard Error				
<i>Overall</i> ⁴	High	19.71	11.56	0.23	0.69				
	Low	9.84	12.10	-0.48	0.72				
3	High	21.33	18.94	-1.42	1.12				
	Low	11.79	18.21	-1.00	1.08				
4	High	9.71	22.05	0.35	1.31				
	Low	-0.68	24.83	-1.87	1.47				
5	High	28.08	18.94	1.75	1.12				
	Low	18.42	18.75	1.43	1.11				

¹LSMeans have been adjusted for sex²Comparisons: Maze X vs Maze Y = (maze trial Y) - (maze trial X)³Time Difference = change in time to complete maze trials, Error Difference = change in errors during maze trials⁴Overall LSMeans have also been adjusted for replicate^bData were square root transformed for analysis and backtransformed to display in this table

Table 17c. Maze Trials, 3 Minute Maximum, LSMeans¹, Only Pigs That Completed Maze Trials Within Time Limit

		Maze 1						Maze 2					
Trait ² :		Time			Errors ^a			Time ^a			Errors ^a		
		95% Confidence Limits			95% Confidence Limits			95% Confidence Limits			95% Confidence Limits		
Replicate	Group	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper
<i>Overall</i> ³	High	75.36	63.91	86.82	3.30	2.83	3.85	48.87	42.33	56.41	0.99	0.67	1.38
	Low	74.21	63.92	84.50	4.47	3.87	5.16	45.41	39.01	52.87	1.17	0.80	1.62
3	High	105.24	87.16	123.32	5.70	4.34	7.48	52.22	41.49	65.71	1.13	0.60	1.82
	Low	85.45	68.55	102.36	4.23	3.26	5.48	45.24	35.95	56.93	1.54	0.91	2.33
4	High	46.28	19.77	72.79	2.72	1.92	3.86	53.83	40.57	71.42	1.15	0.52	2.03
	Low	77.89	55.63	100.15	4.77	3.64	6.27	68.30	50.53	92.32	1.72	0.88	2.84
5	High	74.57	59.73	89.42	2.32*	1.94	2.76	41.53	33.00	52.26	0.72	0.32	1.29
	Low	59.29	45.07	73.50	4.43	3.51	5.59	30.31	23.62	38.90	0.48	0.15	1.01
		Maze 3						Maze 4					
Trait ² :		Time			Errors ^a			Time			Errors ^a		
		95% Confidence Limits			95% Confidence Limits			95% Confidence Limits			95% Confidence Limits		
Replicate	Group	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper
<i>Overall</i> ³	High	58.14	48.30	67.98	3.23	2.54	4.10	52.72	43.11	62.33	3.26†	2.94	3.62
	Low	64.76	55.66	73.86	2.59	2.17	3.09	50.37	40.98	59.76	2.41	2.12	2.75
3	High	31.01	17.18	44.85	3.20	1.78	5.73	47.95	36.00	59.90	3.02	2.64	3.46
	Low	49.90	36.06	63.74	2.43	1.88	3.13	62.74	48.64	76.83	4.29	3.48	5.29
4	High	91.90	70.09	113.71	3.10	2.26	4.26	46.54	25.68	67.41	3.84†	3.07	4.80
	Low	89.42	70.84	108.00	2.90	2.16	3.88	44.98	24.91	65.05	1.84	1.41	2.40
5	High	51.50	36.85	66.15	3.39	2.77	4.14	63.67	47.50	79.83	2.99*	2.55	3.52
	Low	54.96	41.23	68.69	2.47	1.80	3.39	43.39	31.08	55.70	1.78	1.52	2.10
		Maze 5						Maze 6					
Trait ² :		Time			Errors ^a			Time			Errors ^a		
		95% Confidence Limits			95% Confidence Limits			95% Confidence Limits			95% Confidence Limits		
Replicate	Group	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper
<i>Overall</i> ³	High	53.13	39.28	66.97	3.89	2.81	5.39	84.59	66.25	102.93	2.18	1.71	2.79
	Low	69.44	55.87	83.01	Non-estimable			55.25	39.01	71.48	Non-estimable		
3	High	63.66	44.81	82.50	3.39	2.15	5.35	52.86	24.68	81.04	1.73	1.20	2.50
	Low	72.01	48.75	95.27	4.69	2.72	8.10	69.14	40.96	97.32	4.00	2.77	5.78
4	High	40.97	12.91	69.04	5.51	2.96	10.26	103.91	73.04	134.78	2.45	1.56	3.84
	Low	60.01	33.57	86.45	Could Not Calculate ⁴			47.14	18.96	75.32	Could Not Calculate ⁴		
5	High	54.75	32.03	77.47	3.16	1.83	5.46	97.00	62.92	131.08	2.45	1.89	3.18
	Low	76.30	58.60	93.99	3.92	2.29	6.71	49.46	24.46	74.47	4.00	2.77	5.78

¹LSMeans have been adjusted for sex

²Time = time for pig to complete the maze trial, Errors = number of errors during the maze trial

³Overall LSMeans have also been adjusted for replicate

⁴Could not calculate because all Low Pigs from replicate 4 that were available for analysis had 0 errors during maze trials 5 and 6

^aData were log transformed for analysis and backtransformed to display in this table

†Indicates difference between High and Low pigs at P ≤ 0.1

*Indicates significant difference between High and Low pigs at P ≤ 0.05

Table 17d. Maze Trials Differences, 3 Minute Maximum, LSMeans¹, Only Pigs that Completed Maze Trials Within Time Limit

Comparisons ² :		Maze 1 vs Maze 2				Maze 2 vs Maze 3			
Trait ³ :		Time Difference		Error Difference		Time Difference		Error Difference	
Replicate	Group	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error
<i>Overall</i> ⁴	<i>High</i>	-9.95	13.81	0.08	0.90	-3.21	13.12	0.54	0.71
	<i>Low</i>	-18.60	13.00	-0.84	0.84	2.29	11.77	-0.07	0.64
3	<i>High</i>	-3.81	21.82	0.65	1.41	-37.89	17.07	-2.03	0.93
	<i>Low</i>	-39.31	21.82	-0.51	1.41	-13.00	18.07	-1.50	0.98
4	<i>High</i>	-1.08	32.10	-0.46	2.08	31.02	30.82	1.65	1.68
	<i>Low</i>	-10.79	26.88	-0.98	1.74	12.00	22.93	0.54	1.25
5	<i>High</i>	-24.97	17.92	0.04	1.16	-2.75	18.07	2.00	0.98
	<i>Low</i>	-5.71	19.33	-1.02	1.25	7.86	19.26	0.77	1.05
Comparisons ² :		Maze 3 vs Maze 4				Maze 4 vs Maze 5			
Trait ³ :		Time Difference		Error Difference		Time Difference		Error Difference	
Replicate	Group	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error
<i>Overall</i> ⁴	<i>High</i>	-5.78	12.96	-0.11	0.64	-6.03	17.21	-0.23	1.13
	<i>Low</i>	-0.48	12.67	0.05	0.63	27.14	17.33	-0.76	1.13
3	<i>High</i>	18.01	16.72	1.67	0.83	33.88	21.85	-0.17	1.43
	<i>Low</i>	22.17	20.44	1.00	1.02	21.56	25.08	0.18	1.64
4	<i>High</i>	-44.13	26.73	-0.78	1.33	5.04	30.76	2.48	2.01
	<i>Low</i>	-28.69	25.47	-1.23	1.27	22.12	36.59	-3.64	2.39
5	<i>High</i>	8.77	22.47	-1.21	1.12	-57.00	34.32	-3.00	2.25
	<i>Low</i>	5.06	18.31	0.39	0.91	37.72	21.85	1.17	1.43
Comparisons ² :		Maze 5 vs Maze 6							
Trait ³ :		Time Difference		Error Difference					
Replicate	Group	Mean	Standard Error	Mean	Standard Error				
<i>Overall</i> ⁴	<i>High</i>	-5.13	27.04	-0.76	1.67				
	<i>Low</i>	-1.27	18.31	0.16	1.13				
3	<i>High</i>	-32.00	37.03	-2.00	2.29				
	<i>Low</i>	24.40	30.74	2.71	1.90				
4	<i>High</i>	-14.20	40.57	-2.13	2.50				
	<i>Low</i>	-7.27	30.74	0.04	1.90				
5	<i>High</i>	30.80	54.93	1.87	3.39				
	<i>Low</i>	-20.93	30.74	-2.29	1.90				

¹LSMeans have been adjusted for sex

²Comparisons: Maze X vs Maze Y = (maze trial Y) - (maze trial X)

³Time Difference = change in time to complete maze trials, Error Difference = change in errors during maze trials

⁴Overall LSMMeans have also been adjusted for replicate

Table 18a. Wilcoxon Rank-Sum Analysis of Maze Trial Traits, 3 Minute Maximum

		Maze 1								Maze 2								
		Time				Errors				Time				Errors				
Replicate	Trait ¹ Group	N ²	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score
Overall	High	33	1188.5	1105.5	75.26	36.02	1084.0	1105.5	76.92	32.85	1126.5	1105.5	77.94	34.14	1068.5	1105.5	74.89	32.38
	Low	33	1022.5	1105.5	75.26	30.98	1127.0	1105.5	76.92	34.15	1084.5	1105.5	77.94	32.86	1142.5	1105.5	74.89	34.62
3	High	12	164.0	156.0	17.34	13.67	165.0	156.0	18.23	13.75	155.5	156.0	18.38	12.96	146.5	156.0	17.70	12.21
	Low	13	161.0	169.0	17.34	12.38	160.0	169.0	18.23	12.31	169.5	169.0	18.38	13.04	178.5	169.0	17.70	13.73
4	High	9	81.0	76.5	8.57	9.00	62.5†	76.5	9.31	6.94	75.0	76.5	9.42	8.33	74.0	76.5	9.15	8.22
	Low	7	55.0	59.5	8.57	7.86	73.5	59.5	9.31	10.50	61.0	59.5	9.42	8.71	62.0	59.5	9.15	8.86
5	High	12	174.5	156.0	18.26	14.54	154.5	156.0	17.94	12.88	165.0	156.0	18.36	13.75	156.0	156.0	17.20	13.00
	Low	13	150.5	169.0	18.26	11.58	170.5	169.0	17.94	13.12	160.0	169.0	18.36	12.31	169.0	169.0	17.20	13.00
		Maze 3								Maze 4								
		Time				Errors				Time				Errors				
Replicate	Trait ¹ Group	N ²	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score
Overall	High	33	1147.0	1105.5	76.70	34.76	1175.5	1105.5	75.99	35.62	1157.5	1105.5	76.51	35.08	1233.5*	1105.5	75.99	37.38
	Low	33	1064.0	1105.5	76.70	32.24	1035.5	1105.5	75.99	31.38	1053.5	1105.5	76.51	31.92	977.5	1105.5	75.99	29.62
3	High	12	149.0	156.0	18.18	12.42	133.5	156.0	17.13	11.13	128.0†	156.0	18.25	10.67	153.0	156.0	17.53	12.75
	Low	13	176.0	169.0	18.18	13.54	191.5	169.0	17.13	14.73	197.0	169.0	18.25	15.15	172.0	169.0	17.53	13.23
4	High	9	86.0	76.5	9.05	9.56	77.0	76.5	9.29	8.56	80.5	76.5	8.84	8.94	83.0	76.5	9.11	9.22
	Low	7	50.0	59.5	9.05	7.14	59.0	59.5	9.29	8.43	55.5	59.5	8.84	7.93	53.0	59.5	9.11	7.57
5	High	12	167.0	156.0	18.18	13.92	199.5**	156.0	17.97	16.63	196.5*	156.0	18.08	16.38	201.0**	156.0	18.08	16.75
	Low	13	158.0	169.0	18.18	12.15	125.5	169.0	17.97	9.65	128.5	169.0	18.08	9.88	124.0	169.0	18.08	9.54
		Maze 5								Maze 6								
		Time				Errors				Time				Errors				
Replicate	Trait ¹ Group	N ²	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score
Overall	High	33	1124.5	1105.5	69.47	34.08	1112.5	1105.5	76.81	33.71	1136.5	1105.5	61.17	34.44	1147.0	1105.5	77.18	34.76
	Low	33	1086.5	1105.5	69.47	32.92	1098.5	1105.5	76.81	33.29	1074.5	1105.5	61.17	32.56	1064.0	1105.5	77.18	32.24
3	High	12	143.0	156.0	16.28	11.92	147.5	156.0	18.09	12.29	152.0	156.0	13.78	12.67	135.5	156.0	18.16	11.29
	Low	13	182.0	169.0	16.28	14.00	177.5	169.0	18.09	13.65	173.0	169.0	13.78	13.31	189.5	169.0	18.16	14.58
4	High	9	80.0	76.5	8.22	8.89	80.5	76.5	9.20	8.94	79.0	76.5	8.22	8.78	90.0†	76.5	8.84	10.00
	Low	7	56.0	59.5	8.22	8.00	55.5	59.5	9.20	7.93	57.0	59.5	8.22	8.14	46.0	59.5	8.84	6.57
5	High	12	171.0	156.0	16.70	14.25	162.5	156.0	18.12	13.54	168.0	156.0	13.78	14.00	168.5	156.0	18.24	14.04
	Low	13	154.0	169.0	16.70	11.85	162.5	169.0	18.12	12.50	157.0	169.0	13.78	12.08	156.5	169.0	18.24	12.04

¹Time = time for pig to complete the maze trial, Errors = number of errors during the maze trial

²N = number of pigs included in analysis

Table 18b. Wilcoxon Rank-Sum Analysis of Maze Trial Trait Comparisons, 3 Minute Maximum

Comparisons ¹ :		Maze 1 vs Maze 2								Maze 2 vs Maze 3								
Trait ² :		Time				Errors				Time				Errors				
Replicate	Group	N ³	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score
Overall	High	33	1064.0	1105.5	77.97	32.24	1108.0	1105.5	77.58	33.58	1119.0	1105.5	77.97	33.91	1187.0	1105.5	77.22	35.97
	Low	33	1147.0	1105.5	77.97	34.76	1103.0	1105.5	77.58	33.42	1092.0	1105.5	77.97	33.09	1024.0	1105.5	77.22	31.03
3	High	12	151.0	156.0	18.38	12.58	142.5	156.0	18.33	11.88	149.0	156.0	18.38	12.42	143.0	156.0	18.02	11.92
	Low	13	174.0	169.0	18.38	13.38	182.5	169.0	18.33	14.04	176.0	169.0	18.38	13.54	182.0	169.0	18.02	14.00
4	High	9	74.5	76.5	9.44	8.28	83.5	76.5	9.35	9.28	80.0	76.5	9.44	8.89	80.0	76.5	9.41	8.89
	Low	7	61.5	59.5	9.44	8.79	52.5	59.5	9.35	7.50	56.0	59.5	9.44	8.00	56.0	59.5	9.41	8.00
5	High	12	146.0	156.0	18.38	12.17	160.5	156.0	18.23	13.38	170.0	156.0	18.38	14.17	187.0*	156.0	18.15	15.58
	Low	13	179.0	169.0	18.38	13.77	164.5	169.0	18.23	12.65	155.0	169.0	18.38	11.92	138.0	169.0	18.15	10.62
Comparisons ¹ :		Maze 3 vs Maze 4								Maze 4 vs Maze 5								
Trait ² :		Time				Errors				Time				Errors				
Replicate	Group	N ³	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score
Overall	High	33	1105.0	1105.5	77.67	33.48	1166.5	1105.5	77.05	35.35	1058.5	1105.5	77.30	32.08	1017.5	1105.5	77.32	30.83
	Low	33	1106.0	1105.5	77.67	33.52	1044.5	1105.5	77.05	31.65	1152.5	1105.5	77.30	34.92	1193.5	1105.5	77.32	36.17
3	High	12	135.5	156.0	18.37	11.29	172.0	156.0	18.12	14.33	186.5†	156.0	18.26	15.54	149.5	156.0	18.14	12.46
	Low	13	189.5	169.0	18.37	14.58	153.0	169.0	18.12	11.77	138.5	169.0	18.26	10.65	175.5	169.0	18.14	13.50
4	High	9	67.0	76.5	9.05	7.44	79.0	76.5	9.25	8.78	76.0	76.5	9.05	8.44	80.5	76.5	9.34	8.94
	Low	7	69.0	59.5	9.05	9.86	57.0	59.5	9.25	8.14	60.0	59.5	9.05	8.57	55.5	59.5	9.34	7.93
5	High	12	186.0†	156.0	18.37	15.50	166.0	156.0	18.25	13.83	130.5†	156.0	18.34	10.88	128.0†	156.0	18.22	10.67
	Low	13	139.0	169.0	18.37	10.69	159.0	169.0	18.25	12.23	194.5	169.0	18.34	14.96	197.0	169.0	18.22	15.15
Comparisons ¹ :		Maze 5 vs Maze 6																
Trait ² :		Time				Errors												
Replicate	Group	N ³	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score								
Overall	High	33	1099.5	1105.5	71.93	33.32	1161.0	1105.5	77.63	35.18								
	Low	33	1111.5	1105.5	71.93	33.68	1050.0	1105.5	77.63	31.82								
3	High	12	155.5	156.0	16.70	12.96	153.0	156.0	18.31	12.75								
	Low	13	169.5	169.0	16.70	13.04	172.0	169.0	18.31	13.23								
4	High	9	73.0	76.5	8.57	8.11	87.0	76.5	9.35	9.67								
	Low	7	63.0	59.5	8.57	9.00	49.0	59.5	9.35	7.00								
5	High	12	159.5	156.0	17.34	13.29	161.5	156.0	18.27	13.46								
	Low	13	165.5	169.0	17.34	12.73	163.5	169.0	18.27	12.58								

¹Comparisons: Maze X vs Maze Y = (errors during maze trial Y) - (errors during maze trial X)

²Time = time for pig to complete the maze trial, Errors = number of errors during the maze trial

³N = number of pigs included in analysis

Table 19. Maze Trial, 3 Minute Maximum, Completion Frequency¹ and Chi-Squared Values

Replicate	Group	Maze 1		Maze 2		Maze 3		Maze 4		Maze 5		Maze 6							
		Completion Frequencies		Chi-Squared Value		Completion Frequencies		Chi-Squared Value		Completion Frequencies		Chi-Squared Value							
		1	0	1	0	1	0	1	0	1	0	1	0						
Overall	High	54.55	45.45	0.56	96.97	3.03	1.06	63.64	36.36	0.63	63.64	36.36	0.27	39.39	60.61	0.06	24.24	75.76	0.31
	Low	63.64	36.36		90.91	9.09		72.73	27.27		69.70	30.30		42.42	57.58		30.30	69.70	
3	High	50.00	50.00	0.04	100.00	0.00	0.96	75.00	25.00	0.10	91.67	8.33	3.11†	50.00	50.00	0.96	25.00	75.00	0.01
	Low	53.85	46.15		92.31	7.69		69.23	30.77		61.54	38.46		30.77	69.23		23.08	76.92	
4	High	42.86	57.14	0.29	100.00	0.00	-	57.14	42.86	0.31	57.14	42.86	0.00	42.86	57.14	0.00	42.86	57.14	0.00
	Low	57.14	42.86		100.00	0.00		71.43	28.57		57.14	42.86		42.86	57.14		42.86	57.14	
5	High	75.00	25.00	2.89†	100.00	0.00	-	66.67	33.33	4.07*	50.00	50.00	6.88**	33.33	66.67	2.93†	16.67	83.33	1.50
	Low	100.00	0.00		100.00	0.00		100.00	0.00		100.00	0.00		70.00	30.00		40.00	60.00	

¹Completion Frequency = percentage of pigs in group that completed maze within allotted time; 1 = completed, 0 = did not complete

†Indicates difference between High and Low pigs at $P \leq 0.1$

*Indicates significant difference between High and Low pigs at $P \leq 0.05$

**Indicates significant difference between High and Low pigs at $P \leq 0.01$

Table 20a. Cardiac Response¹ During Novel Object Test 1

Replicate	Group	Baseline ²		+5(s) ³		+10(s) ³		+15(s) ³		+20(s) ³		+25(s) ³		+30(s) ³		+35(s) ³		+40(s) ³		+45(s) ³	
		Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM
<i>Overall</i> ⁴	High	176.15†	3.60	2.95	2.54	4.06	2.62	2.67	2.70	2.51	2.75	1.98	2.92	3.40	3.09	4.15	3.13	4.14	3.17	5.12	3.33
	Low	167.31	3.51	2.78	2.48	3.04	2.56	1.78	2.63	1.59	2.68	3.25	2.85	3.66	3.01	3.28	3.05	4.68	3.09	4.20	3.25
1	High	188.22	6.97	1.59	4.92	3.12	5.08	4.82	5.23	4.11	5.33	2.94	5.67	3.80	5.99	6.01	6.07	3.80	6.14	4.31	6.46
	Low	177.75	7.20	9.40	5.08	9.09	5.24	8.81	5.40	11.20	5.50	10.92	5.86	9.27	6.18	8.17	6.27	5.29	6.34	6.08	6.67
2	High	175.66**	9.87	-1.64	6.97	-0.13	7.19	-2.22	7.40	0.80	7.54	-0.32	8.03	-0.68	8.48	-0.36	8.59	1.15	8.70	2.98	9.14
	Low	131.12	8.69	6.53	6.14	4.24	6.33	1.87	6.52	-3.15	6.64	0.50	7.07	0.33	7.46	-1.47	7.57	4.69	7.66	3.93	8.05
3	High	161.80	7.20	4.82	5.08	7.66	5.24	5.84	5.40	2.62	5.50	1.26	5.86	5.99	6.18	5.44	6.27	5.71	6.34	5.04	6.67
	Low	166.96	7.50	0.19	5.30	1.47	5.46	1.98	5.63	-0.62	5.74	-0.10	6.10	-0.51	6.44	-0.06	6.53	0.44	6.61	-0.44	6.95
4	High	175.44	8.27	6.69	5.84	6.03	6.02	3.41	6.20	3.83	6.32	4.39	6.73	6.68	7.10	7.19	7.20	6.89	7.29	9.80	7.66
	Low	187.78	8.20	2.62	5.79	5.22	5.98	2.52	6.15	6.32	6.27	9.02	6.68	11.22	7.05	12.52	7.14	10.82	7.23	9.82	7.60
5	High	179.62	7.20	3.29	5.08	3.61	5.24	1.50	5.40	1.19	5.50	1.62	5.86	1.20	6.18	2.45	6.27	3.18	6.34	3.46	6.67
	Low	172.95	7.32	-4.82	5.17	-4.82	5.34	-6.30	5.49	-5.78	5.60	-4.08	5.96	-2.03	6.29	-2.75	6.38	2.14	6.46	1.60	6.79
Replicate	Group	+50(s) ³		+55(s) ³		+60(s) ³		+90(s) ³		+120(s) ³		+150(s) ³		+180(s) ³		+210(s) ³		+240(s) ³		+270(s) ³	
		Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM
<i>Overall</i> ⁴	High	4.79	3.36	4.20	3.45	3.99	3.48	1.96	3.83	4.01	4.07	3.31	4.23	2.84	4.33	-1.21	4.19	4.41	4.23	3.89	4.38
	Low	3.84	3.28	4.20	3.36	5.33	3.39	3.26	3.74	-0.28	3.97	2.85	4.13	0.96	4.23	7.08	4.09	4.65	4.12	5.64	4.28
1	High	1.93	6.51	-0.08	6.69	-3.06	6.74	-8.71	7.43	-9.20	7.90	-10.28	8.20	-10.25	8.40	-11.31	8.13	-6.08	8.20	-3.84	8.50
	Low	6.40	6.72	4.90	6.90	3.67	6.96	-5.19	7.67	-8.69	8.15	-9.75	8.47	-8.88	8.67	-3.88	8.39	-8.87	8.46	-4.94	8.78
2	High	4.48	9.21	2.68	9.46	2.99	9.54	5.02	10.51	8.96	11.17	14.49	11.61	7.50	11.89	4.09	11.50	13.26	11.60	9.29	12.03
	Low	2.98	8.11	7.72	8.33	12.14	8.41	7.34	9.26	13.72	9.84	18.09	10.22	11.97	10.47	14.29	10.13	15.16	10.21	12.47	10.60
3	High	7.36	6.72	7.31	6.90	5.55	6.96	1.68	7.67	10.57	8.15	2.66	8.47	10.69	8.67	0.77	8.39	4.32	8.46	1.01	8.78
	Low	0.37	7.01	-1.79	7.19	-3.39	7.26	6.07	7.99	3.57	8.49	10.45	8.83	10.72	9.04	10.97	8.75	7.87	8.82	13.86	9.15
4	High	7.37	7.72	8.85	7.93	6.08	8.00	11.67	8.80	5.18	9.36	4.47	9.73	4.22	9.96	-4.57	9.64	-1.04	9.72	4.29	10.08
	Low	10.02	7.66	10.12	7.87	10.82	7.94	5.12	8.74	-6.48	9.29	-3.58	9.65	-3.38	9.88	13.42	9.57	7.62	9.64	2.62	10.00
5	High	2.84	6.72	2.26	6.90	8.41	6.96	0.12	7.67	4.54	8.15	5.22	8.47	2.04	8.67	4.96	8.39	11.57	8.46	8.72	8.78
	Low	-0.57	6.84	0.03	7.02	3.38	7.09	2.98	7.80	-3.53	8.29	-0.96	8.62	-5.62	8.82	0.59	8.54	1.48	8.61	4.21	8.93

¹Cardiac Response = Change in heart rate in response to introduction of novel object to test area; all means have been adjusted for sex

²Baseline = Average heart rates over the 60 seconds preceding novel object introduction

³+X(s) = Average difference between heart rate at specified time (in seconds) and the baseline heart rate

⁴Overall means have also been adjusted for replicate

†Indicates difference between High and Low pigs at P ≤ 0.1

**Indicates significant difference between High and Low pigs at P ≤ 0.01

Table 20b. Cardiac Response¹ During Novel Object Test 2

Replicate	Group	Baseline ²		+5(s) ³		+10(s) ³		+15(s) ³		+20(s) ³		+25(s) ³		+30(s) ³		+35(s) ³		+40(s) ³		+45(s) ³	
		Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM
<i>Overall</i> ⁴	High	182.11	3.21	5.51	1.70	6.42	1.97	4.59	2.03	3.58	2.10	3.72	2.11	2.81	2.06	1.48	2.53	1.57	3.01	1.89	2.85
	Low	183.82	2.92	5.89	1.54	4.73	1.79	3.57	1.85	3.91	1.91	3.21	1.92	2.69	1.88	2.36	2.30	1.05	2.74	2.37	2.59
1	High	183.50	6.13	6.90	3.24	8.78	3.75	2.08	3.87	-2.01	4.01	-3.54	4.02	-3.87	3.94	-1.21	4.83	-1.11	5.75	-0.66	5.44
	Low	178.55	6.12	7.38	3.23	3.80	3.74	3.65	3.86	2.46	4.00	2.39	4.01	4.10	3.92	2.76	4.82	2.64	5.74	2.12	5.43
2	High	177.62	8.38	6.26	4.43	7.46	5.13	8.74	5.29	11.86	5.48	14.73	5.50	12.12	5.38	12.35	6.60	14.39	7.86	14.08	7.44
	Low	183.32	7.02	4.55	3.71	5.26	4.30	4.08	4.44	4.83	4.60	3.22	4.61	1.62	4.51	2.31	5.53	2.74	6.59	4.03	6.23
3	High	174.22	6.12	2.09	3.23	3.75	3.74	2.59	3.86	3.48	4.00	4.02	4.01	3.43	3.92	5.62	4.82	5.81	5.74	3.98	5.43
	Low	170.38	6.12	5.31	3.23	8.81	3.74	6.97	3.86	8.00	4.00	9.07	4.01	7.98	3.92	6.32	4.82	7.06	5.74	4.50	5.43
4	High	203.96	7.81	3.93	4.13	3.17	4.78	0.79	4.93	-2.31	5.11	-2.80	5.12	-1.48	5.01	-12.60	6.15	-14.00	7.33	-13.93	6.93
	Low	192.68	6.97	5.23	3.68	1.53	4.26	0.53	4.40	1.33	4.56	0.23	4.57	-1.08	4.47	-0.38	5.49	-1.28	6.54	-0.68	6.19
5	High	171.23*	6.97	8.37	3.68	8.97	4.26	8.77	4.40	6.87	4.56	6.17	4.57	3.87	4.47	3.27	5.49	2.77	6.54	5.97	6.19
	Low	194.16	6.23	6.96	3.29	4.25	3.81	2.65	3.93	2.94	4.07	1.14	4.08	0.86	4.00	0.81	4.90	-5.89	5.84	1.89	5.52
Replicate	Group	+50(s) ³		+55(s) ³		+60(s) ³		+90(s) ³		+120(s) ³		+150(s) ³		+180(s) ³		+210(s) ³		+240(s) ³		+270(s) ³	
		Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM
<i>Overall</i> ⁴	High	1.31	2.91	1.22	2.85	5.19	2.57	4.89	2.50	3.49	2.01	3.04	2.52	3.51	2.53	4.03	3.43	-0.09	3.46	1.50	3.58
	Low	3.34	2.65	3.29	2.59	2.10	2.34	2.97	2.27	1.55	1.79	-0.53	2.25	-0.08	2.25	1.28	3.06	-2.18	3.08	-3.92	3.19
1	High	-1.21	5.56	-1.45	5.45	-0.59	4.91	-1.17	4.77	3.82†	3.76	4.69	4.72	5.56	4.73	10.10	6.42	2.43	6.47	7.64	6.70
	Low	1.81	5.54	1.63	5.43	3.09	4.90	-1.41	4.76	-4.98	3.75	-5.61	4.70	-4.35	4.72	-1.14	6.40	-3.06	6.45	-3.11	6.68
2	High	11.20	7.60	7.48	7.44	9.64	6.71	8.57	6.52	-6.41†	5.54	-1.16	6.94	-5.01	6.96	0.05	9.44	-7.76	9.53	-5.50	9.86
	Low	4.05	6.37	3.18	6.24	2.27	5.63	10.77	5.46	5.42	4.31	2.72	5.40	4.04	5.42	1.87	7.35	-11.76	7.41	-16.77	7.67
3	High	3.60	5.54	2.65	5.43	4.50	4.90	10.00	4.76	8.27†	3.75	10.87*	4.70	7.75*	4.72	3.42	6.40	11.58*	6.45	16.37*	6.68
	Low	5.19	5.54	3.45	5.43	1.99	4.90	1.72	4.76	-0.95	3.75	-3.85	4.70	-6.50	4.72	-1.24	6.40	-6.40	6.45	-3.96	6.68
4	High	-13.69	7.08	-11.65	6.93	2.73	6.26	0.86	6.07	1.01	4.79	-5.55	6.01	-3.81	6.02	-5.27	8.17	-14.37†	8.25	-17.68*	8.53
	Low	0.73	6.32	1.73	6.19	-0.78	5.58	1.43	5.42	5.93	4.28	3.13	5.36	0.73	5.37	1.43	7.29	4.13	7.36	5.13	7.61
5	High	6.67	6.32	9.07	6.19	9.67	5.58	6.17	5.42	10.77	4.28	6.37	5.36	13.07	5.37	11.87	7.29	7.67	7.36	6.67	7.61
	Low	4.92	5.64	6.48	5.53	3.93	4.99	2.35	4.84	2.33	3.82	0.99	4.79	5.67	4.80	5.47	6.51	6.19	6.57	-0.88	6.80

¹Cardiac Response = Change in heart rate in response to introduction of novel object to test area; all means have been adjusted for sex²Baseline = Average heart rates over the 60 seconds preceding novel object introduction³+X(s) = Average difference between heart rate at specified time (in seconds) and the baseline heart rate; have been adjusted for sex⁴Overall means have also been adjusted for replicate

†Indicates difference between High and Low pigs at P ≤ 0.1

*Indicates significant difference between High and Low pigs at P ≤ 0.05

**Indicates significant difference between High and Low pigs at P ≤ 0.01

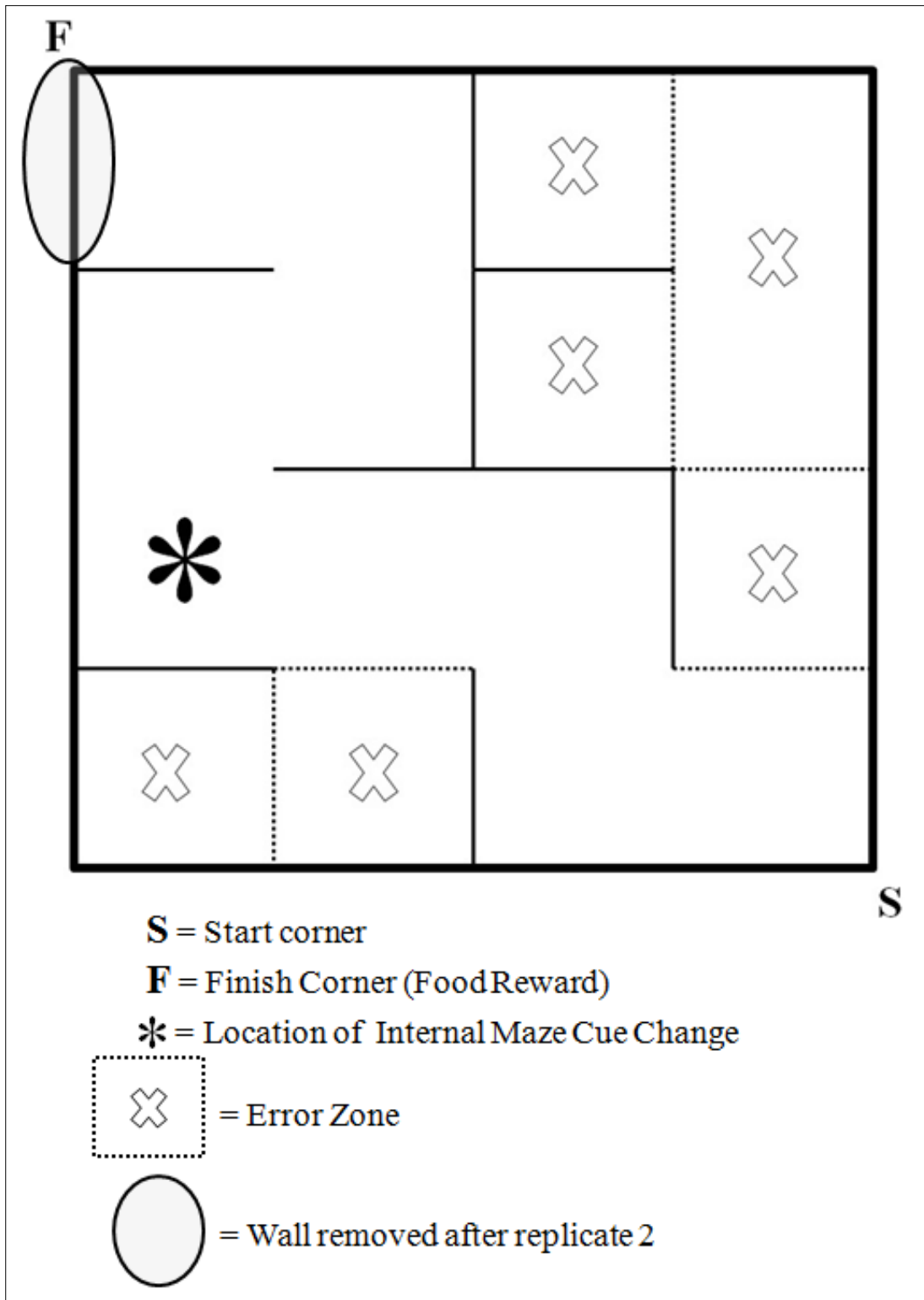


Figure 1. Maze Configuration

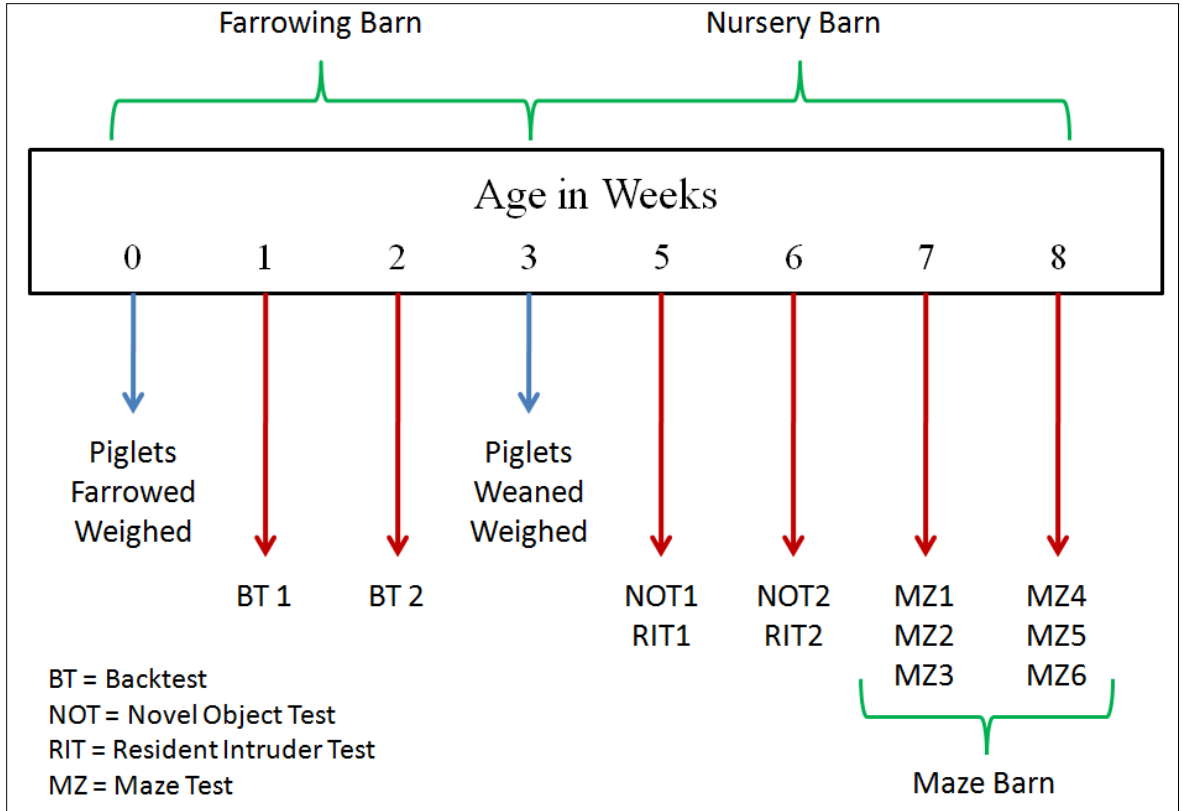


Figure 2. Timeline of Tests and Measurements

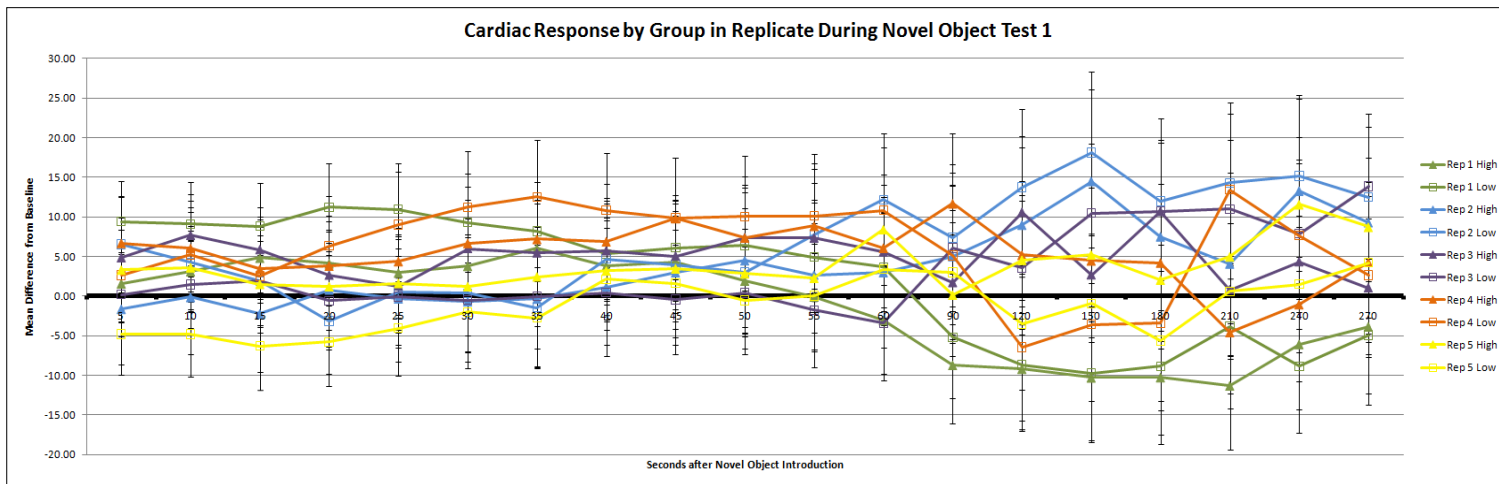


Figure 3a. Cardiac Response to Novelty During Novel Object Test 1

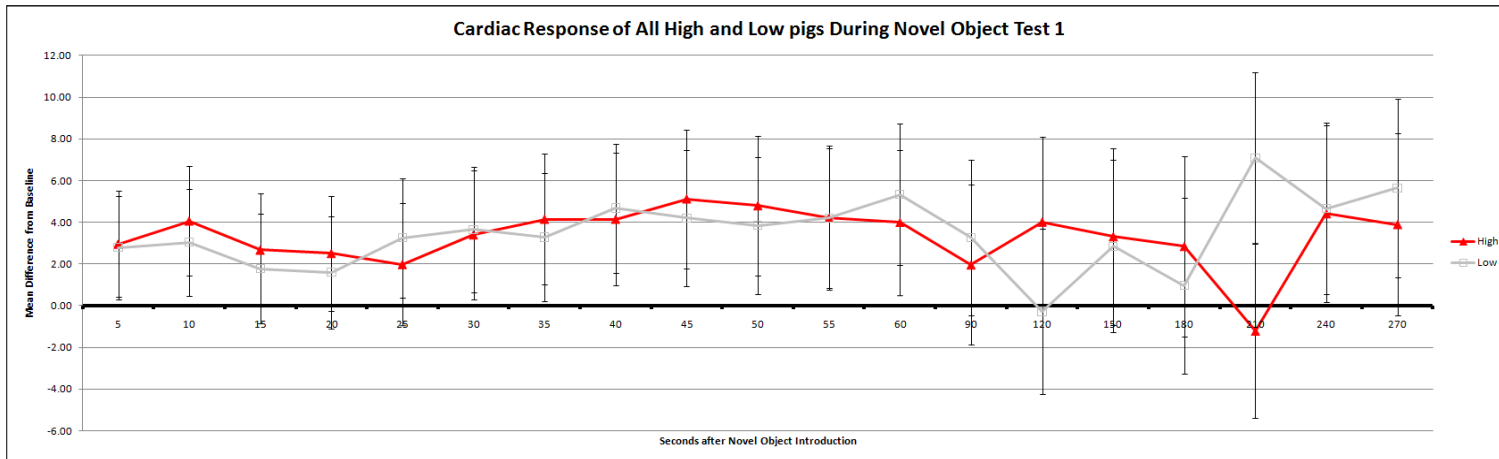


Figure 3b. Cardiac Response to Novelty During Novel Object Test 1, Overall

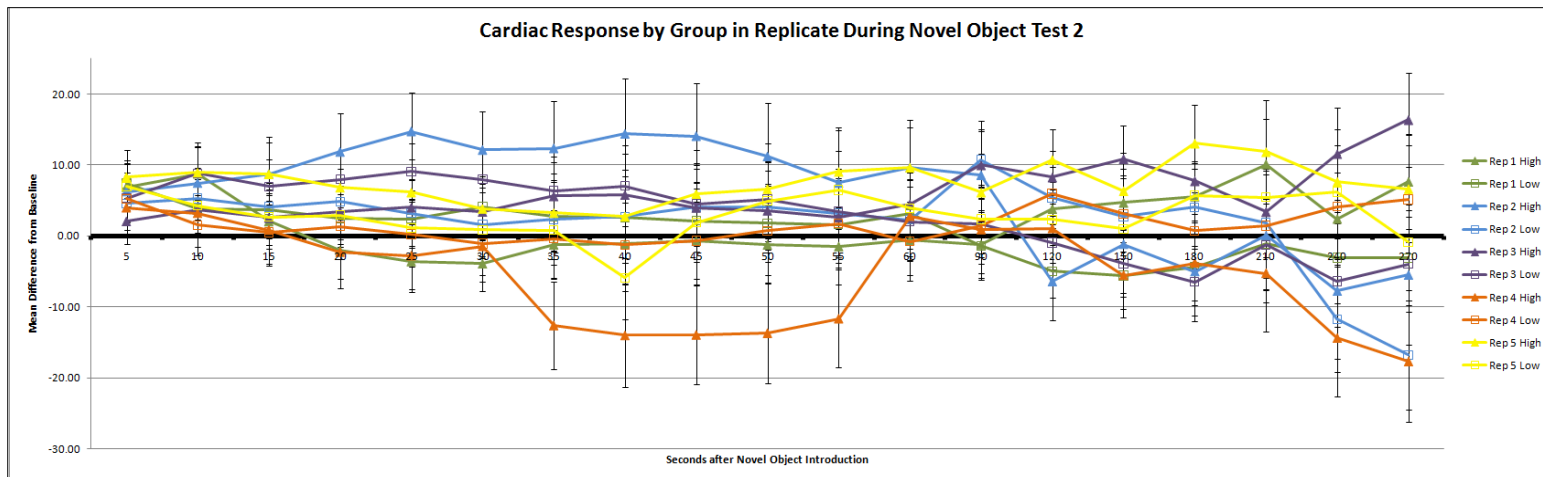


Figure 4a. Cardiac Response to Novelty During Novel Object Test 2

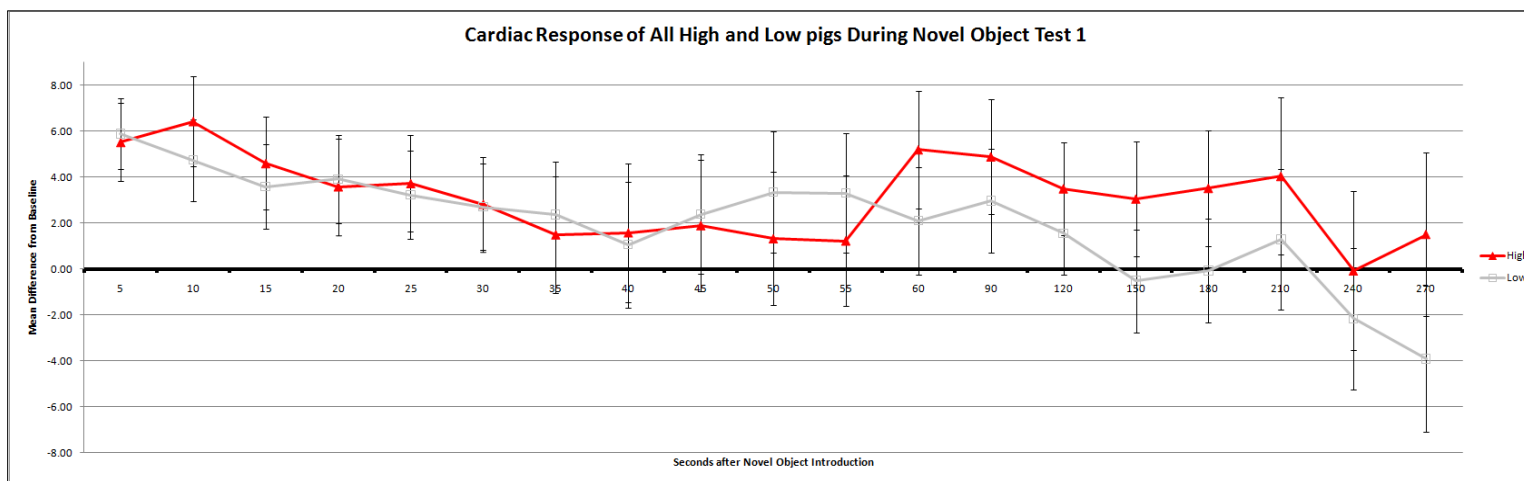


Figure 4b. Cardiac Response to Novelty During Novel Object Test 2, Overall

Appendix

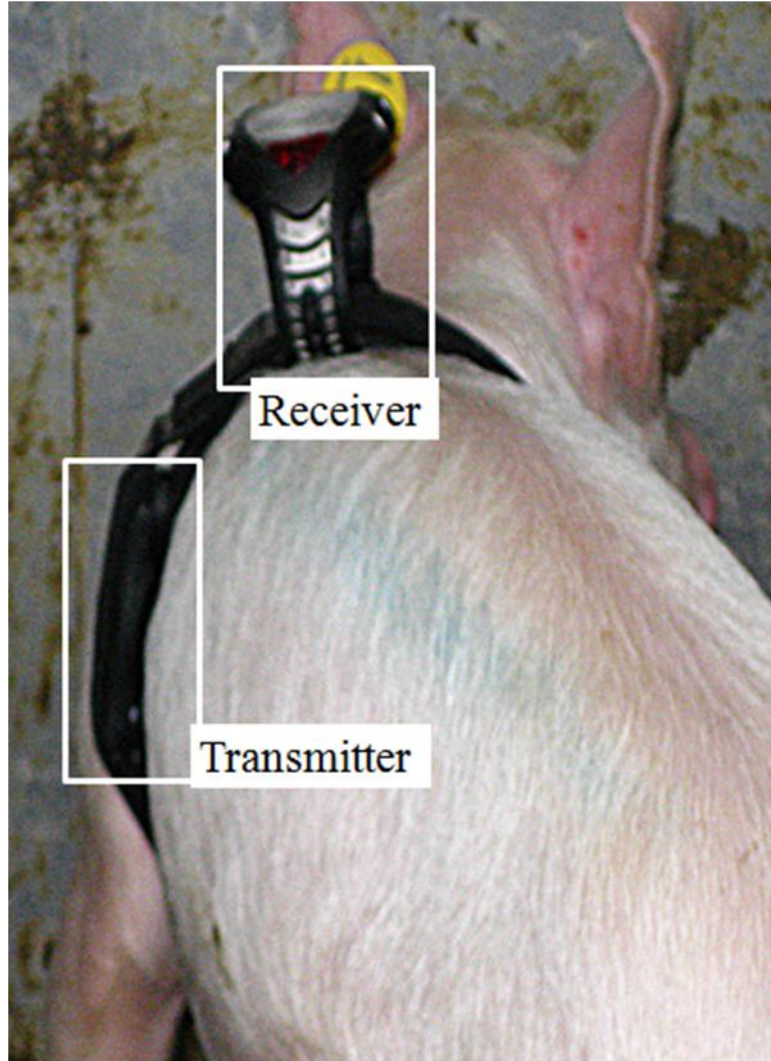


Figure A1. Heart Rate Monitor Apparatus

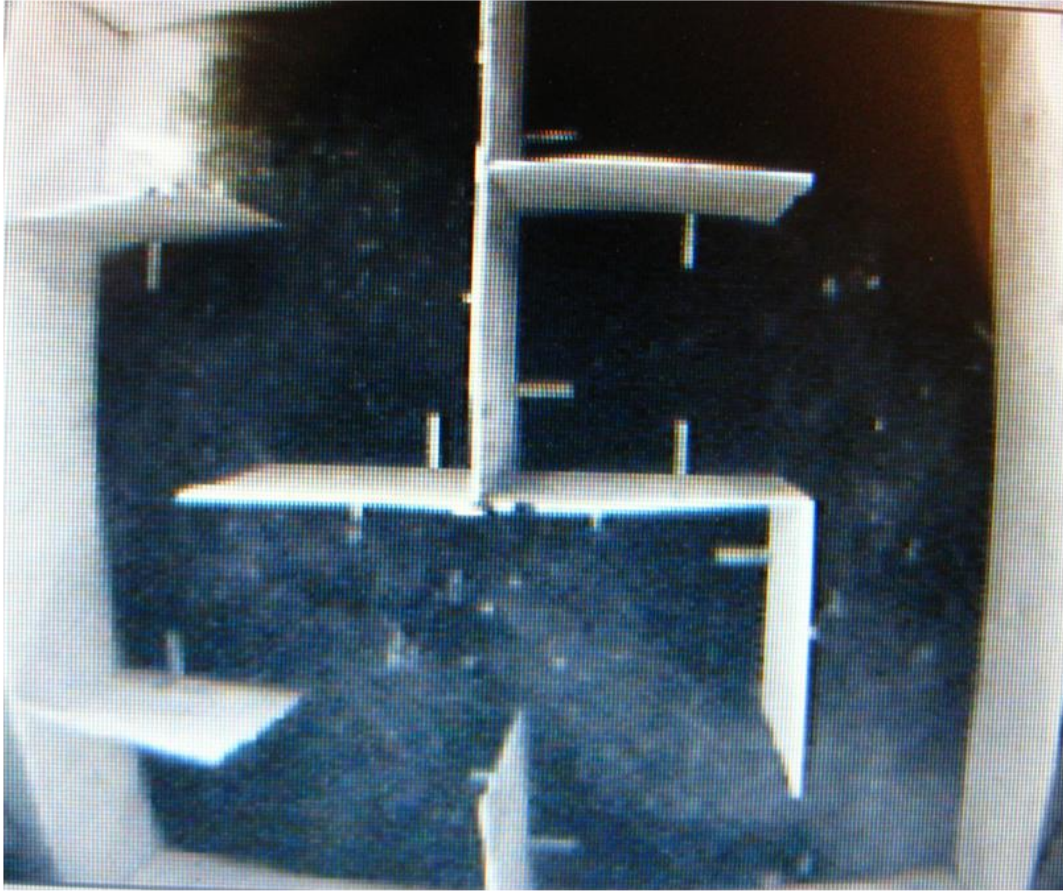


Figure A2. Maze Configuration



Figure A3. Maze Modification

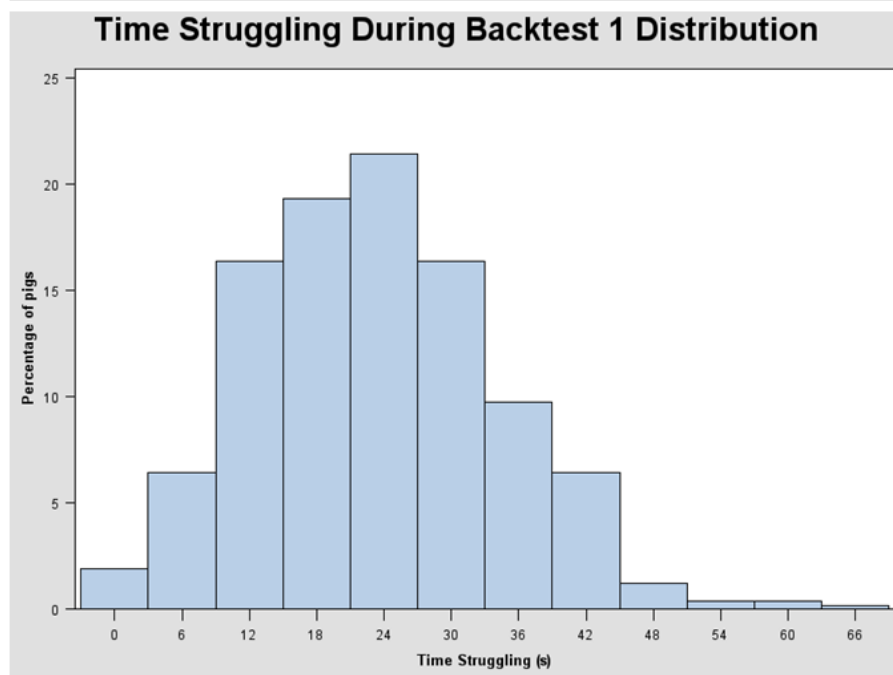
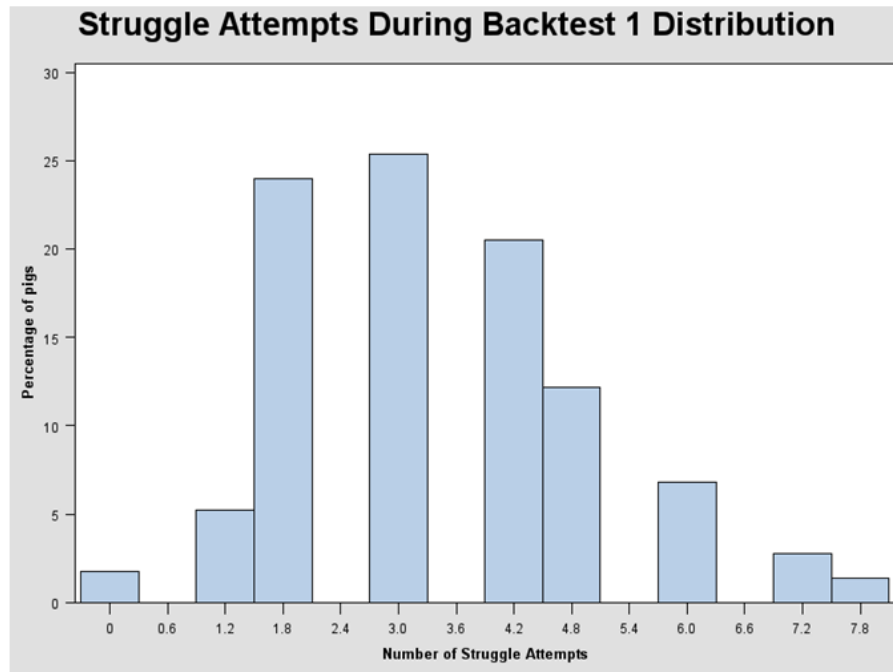


Figure A4. Backtest1 Measurements Distributions

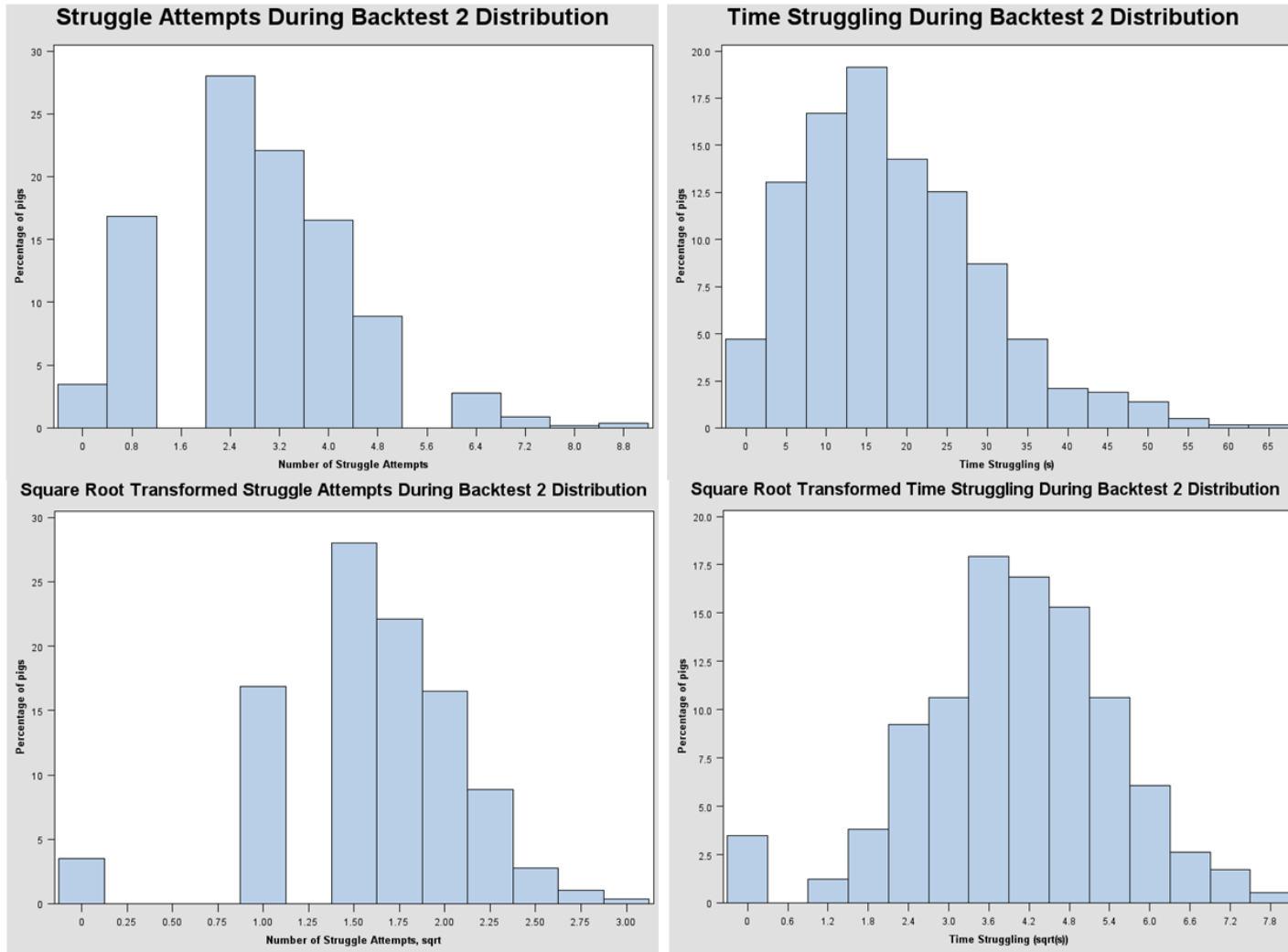


Figure A5. Backtest 2 Measurements Distributions

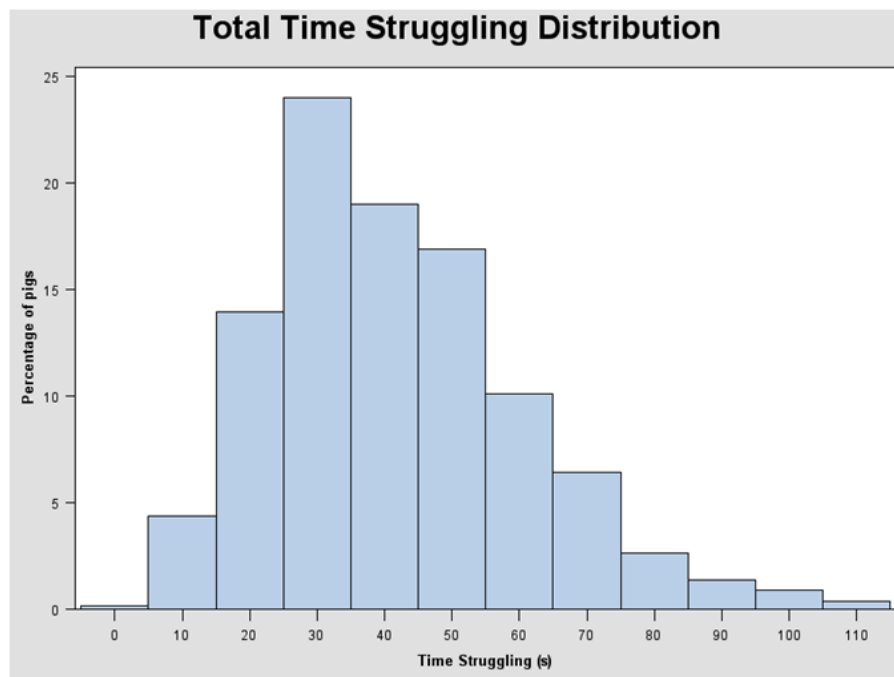
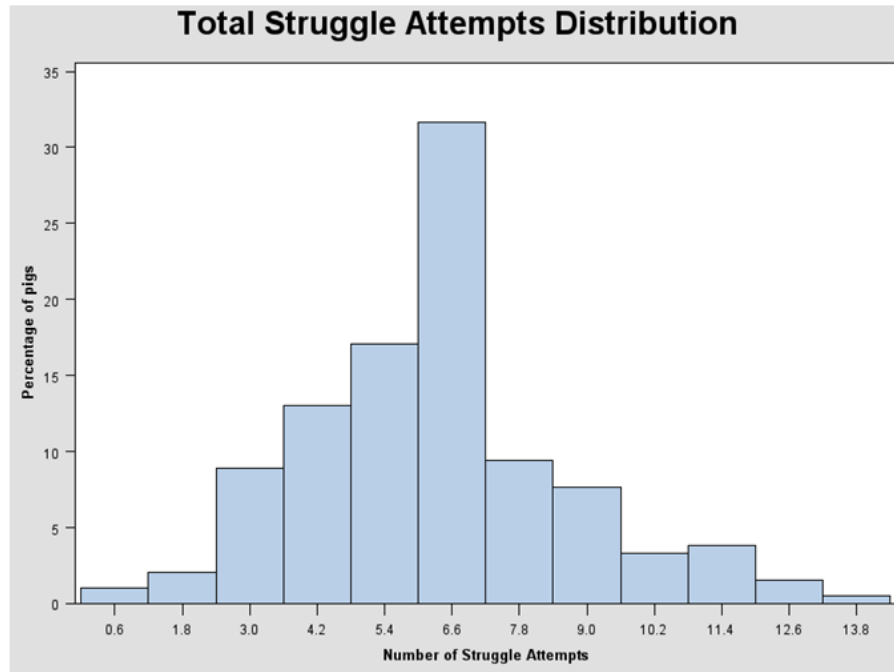


Figure A6. Backtest Overall Measurements Distributions

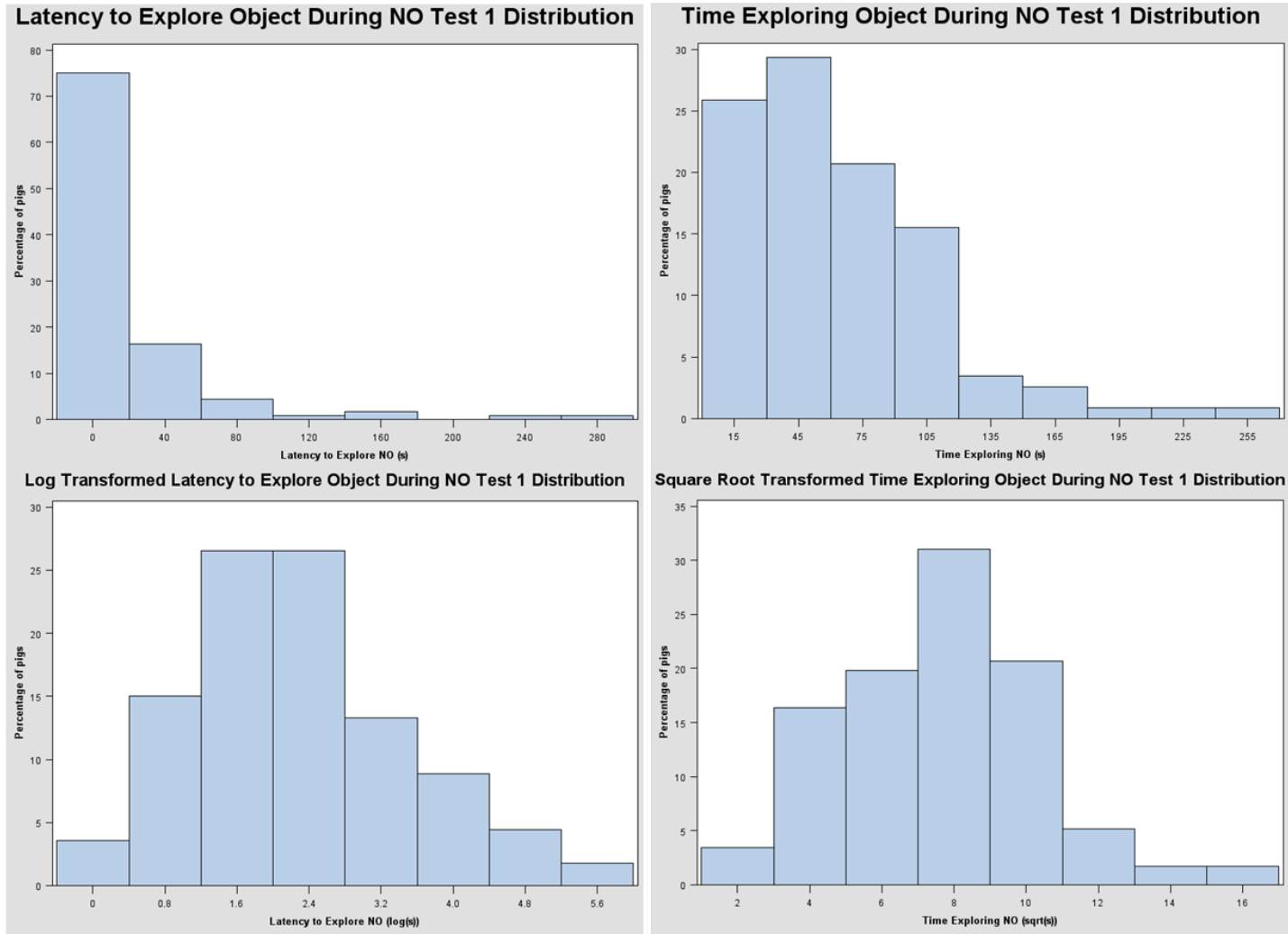


Figure A7. Novel Object Test 1 Measurements Distributions

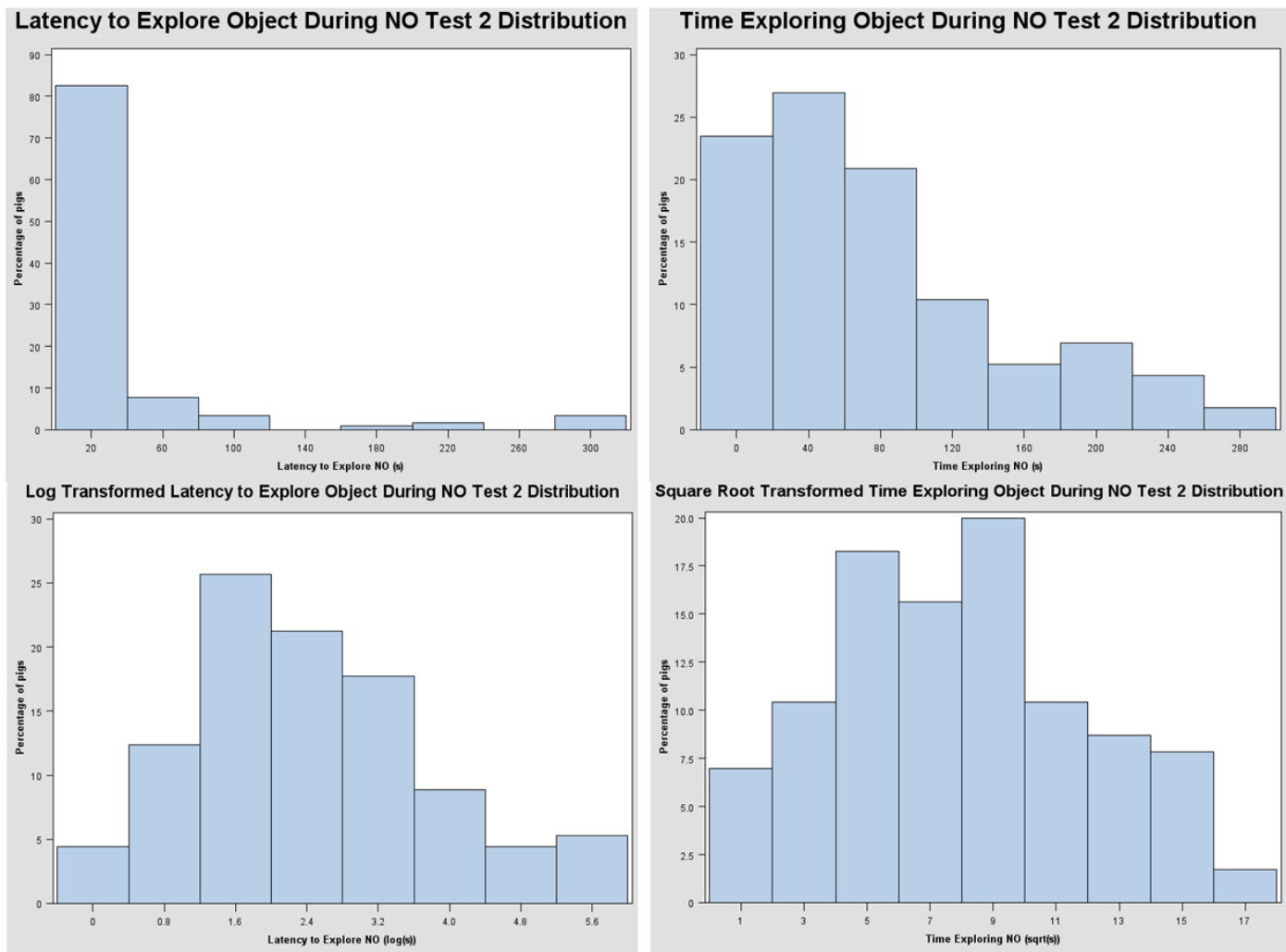


Figure A8. Novel Object Test 2 Measurements Distributions

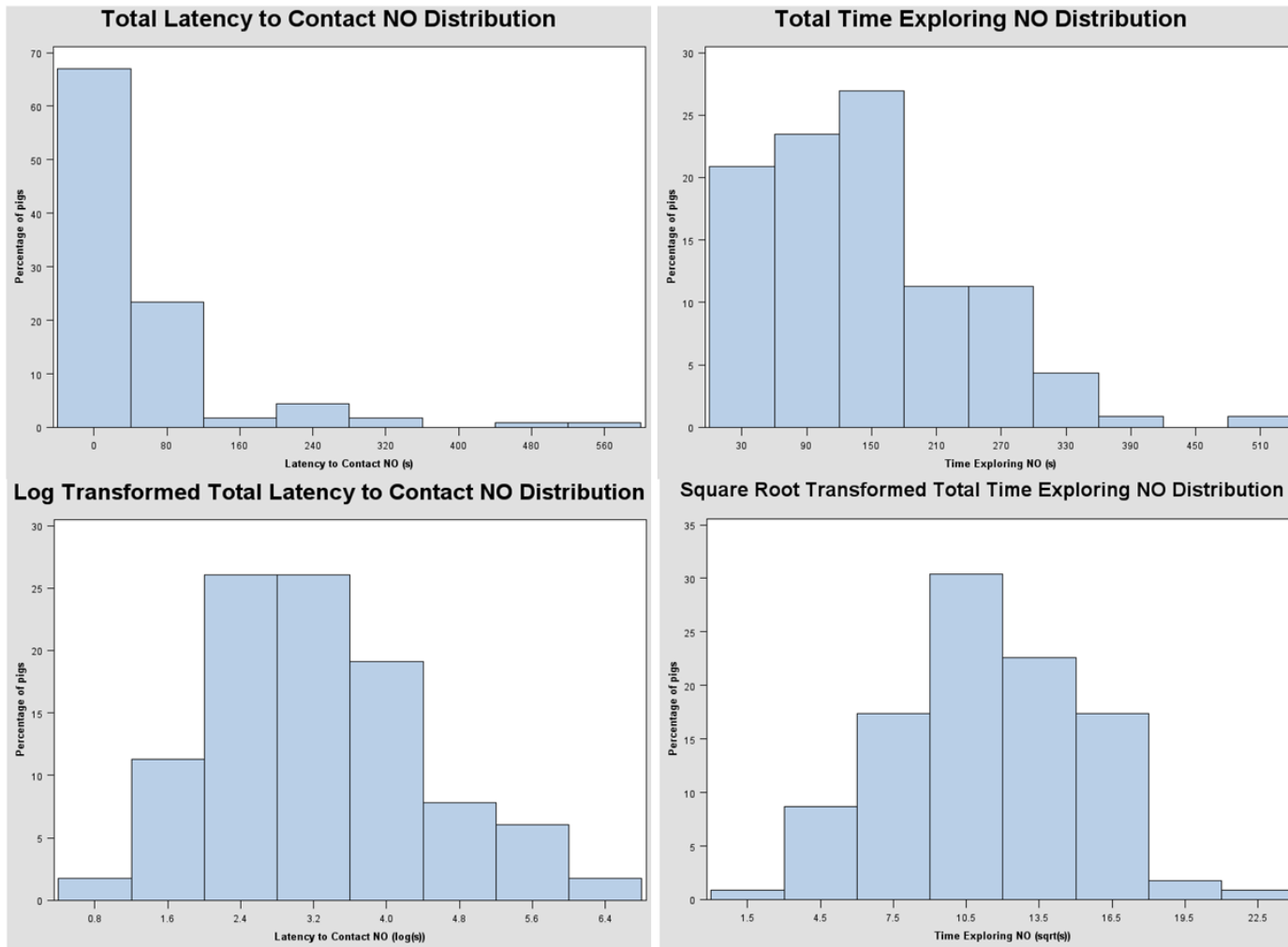


Figure A9. Novel Object Overall Measurements Distributions

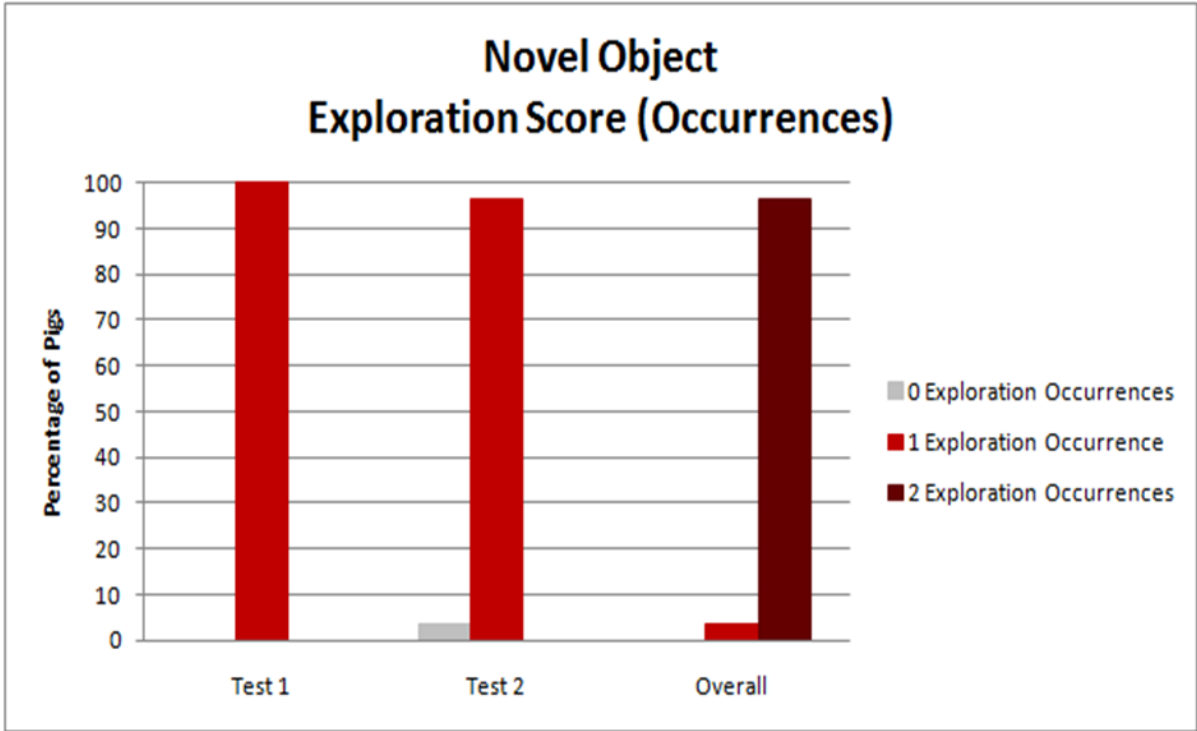


Figure A10. Novel Object Exploration Scores Distributions

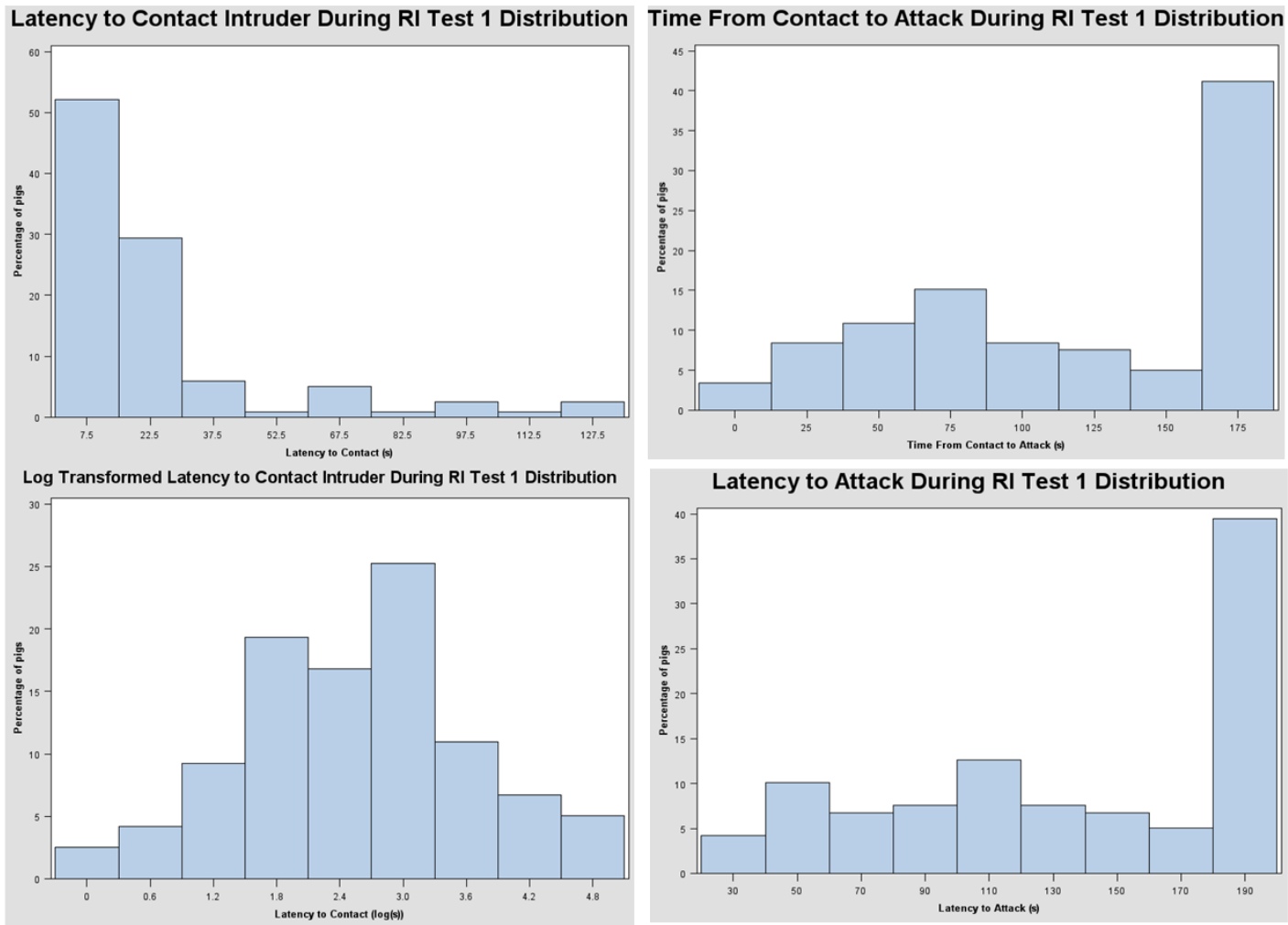


Figure A11. Resident Intruder Test 1 Measurements Distributions

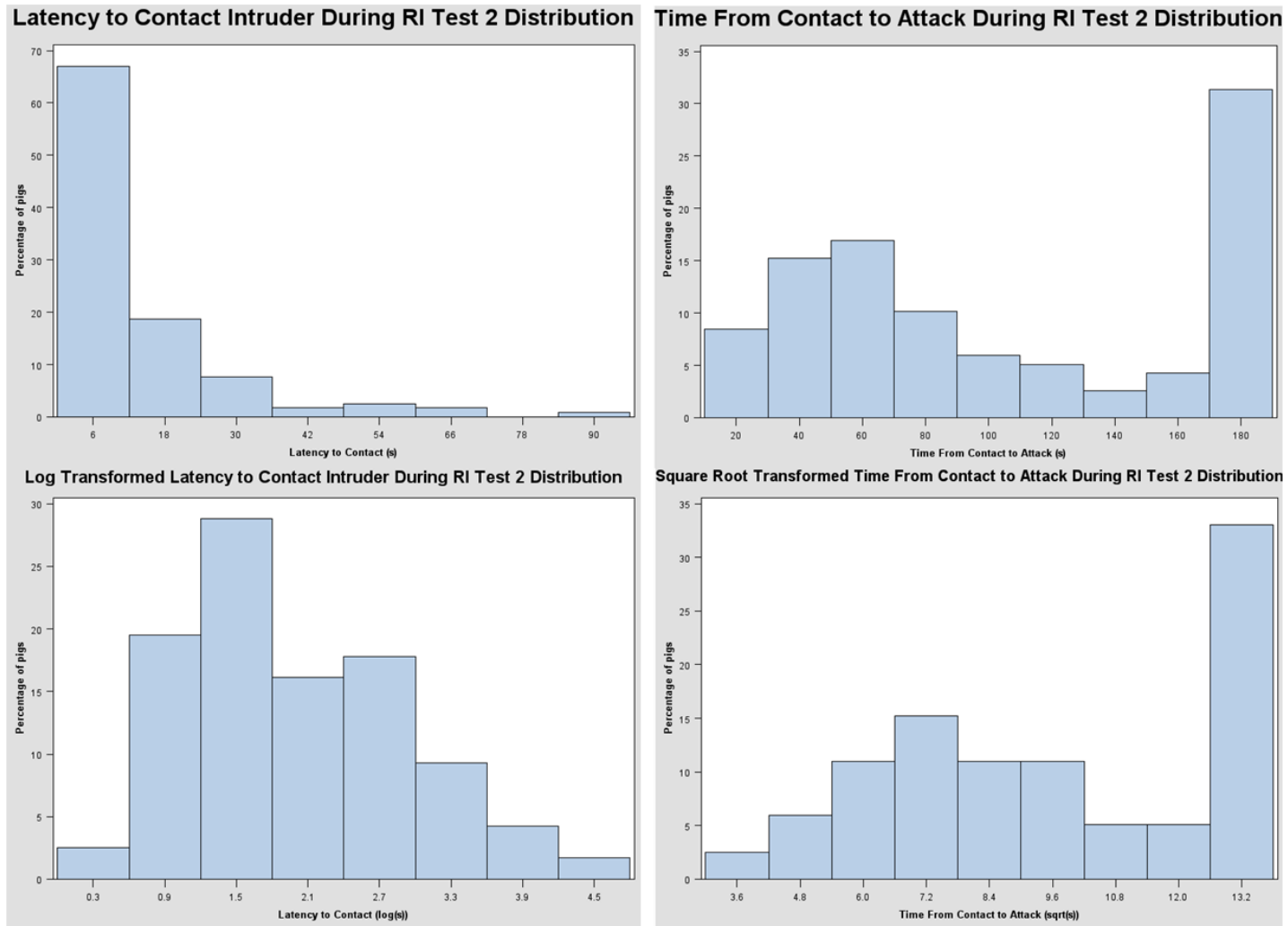


Figure A12. Resident Intruder Test 2 Measurements Distributions

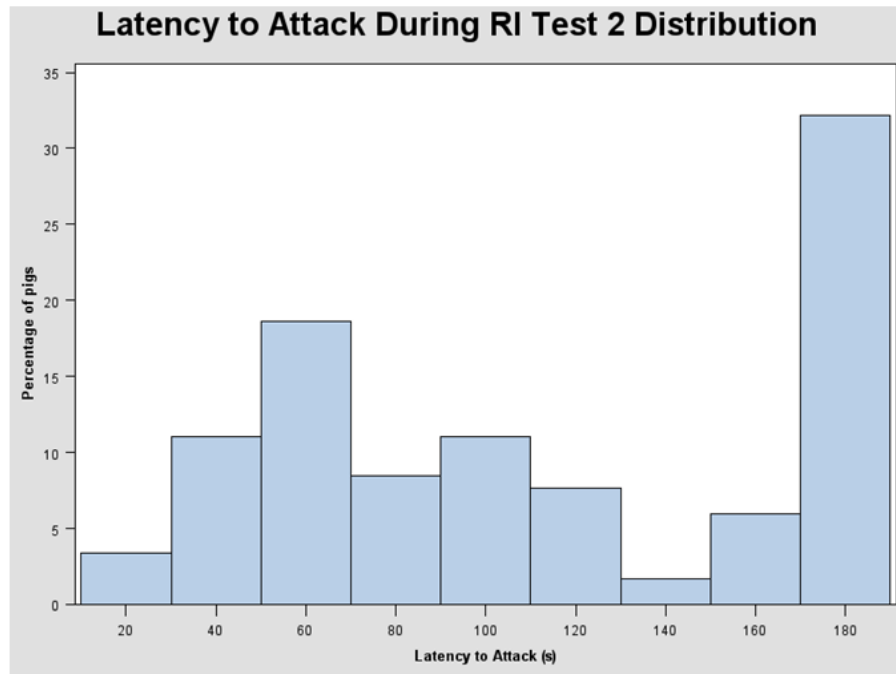


Figure A12. Continued

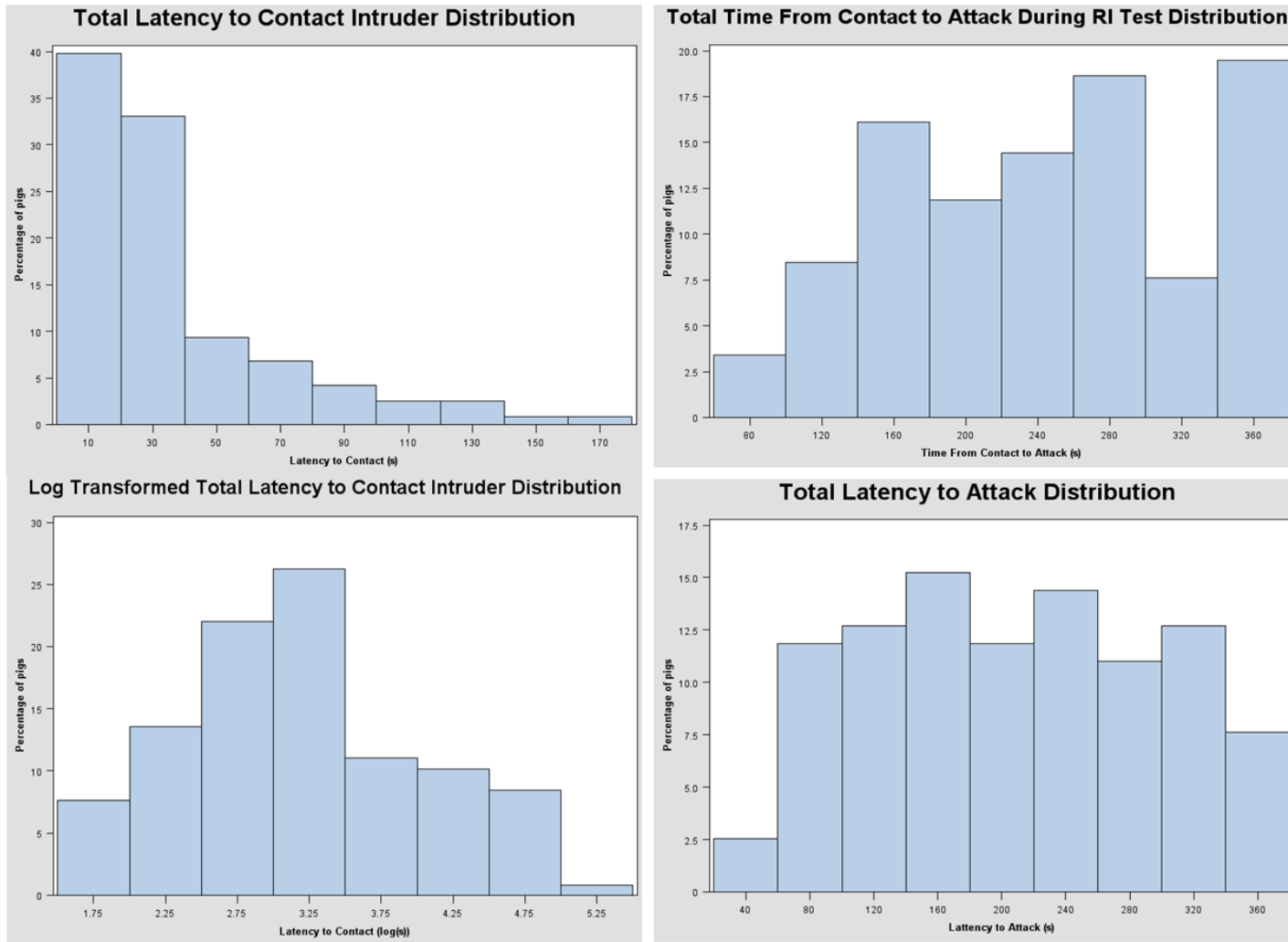


Figure A13. Resident Intruder Test Overall Distributions

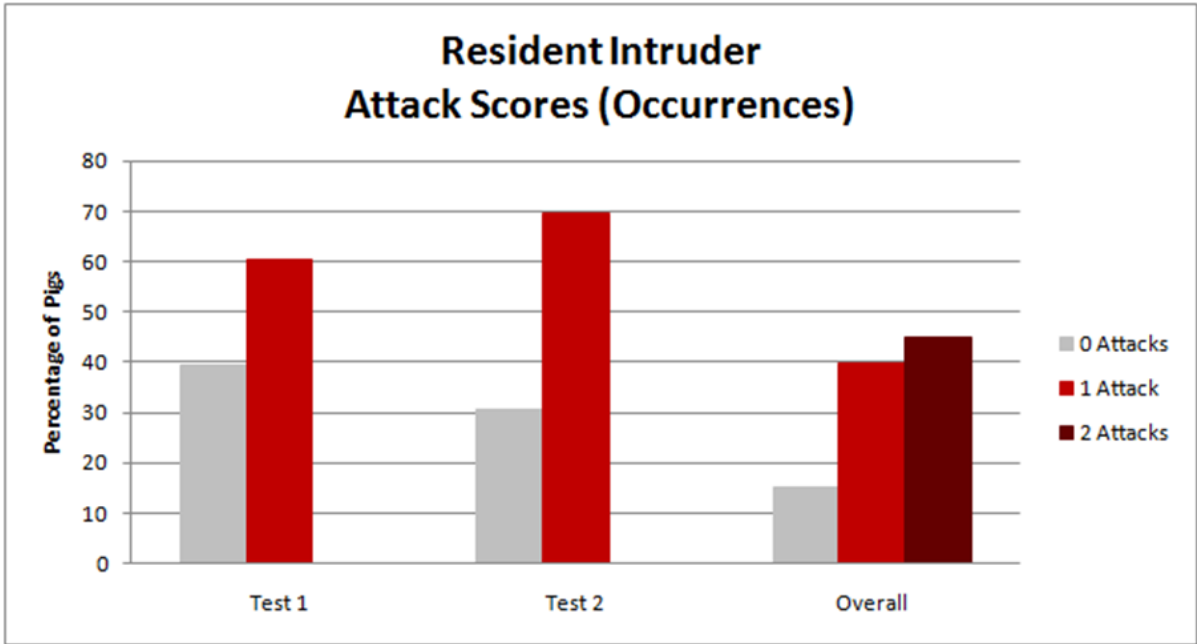


Figure A14. Resident Intruder Attack Scores Distributions

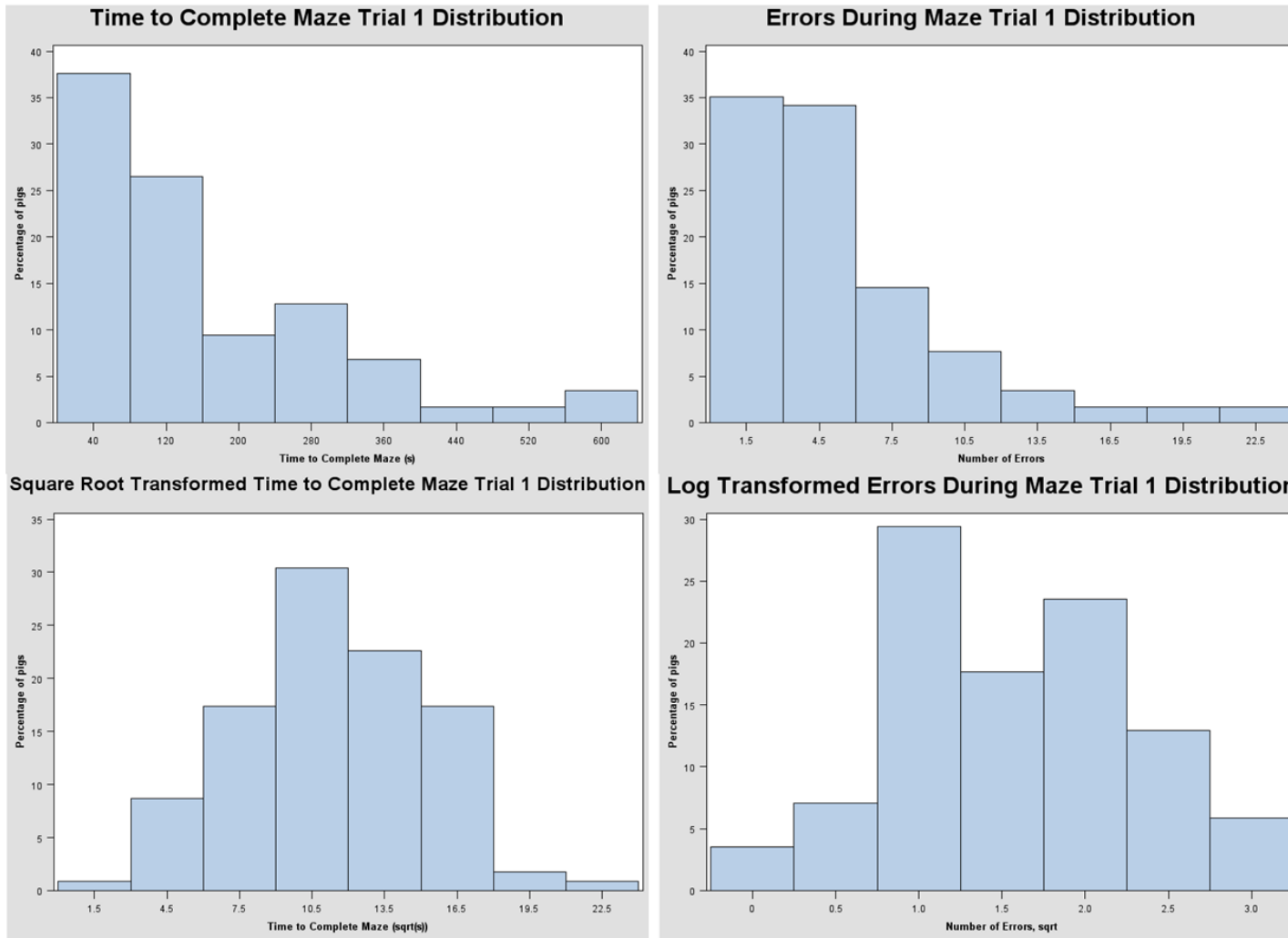


Figure A15. Maze Trial 1 Measurements Distributions

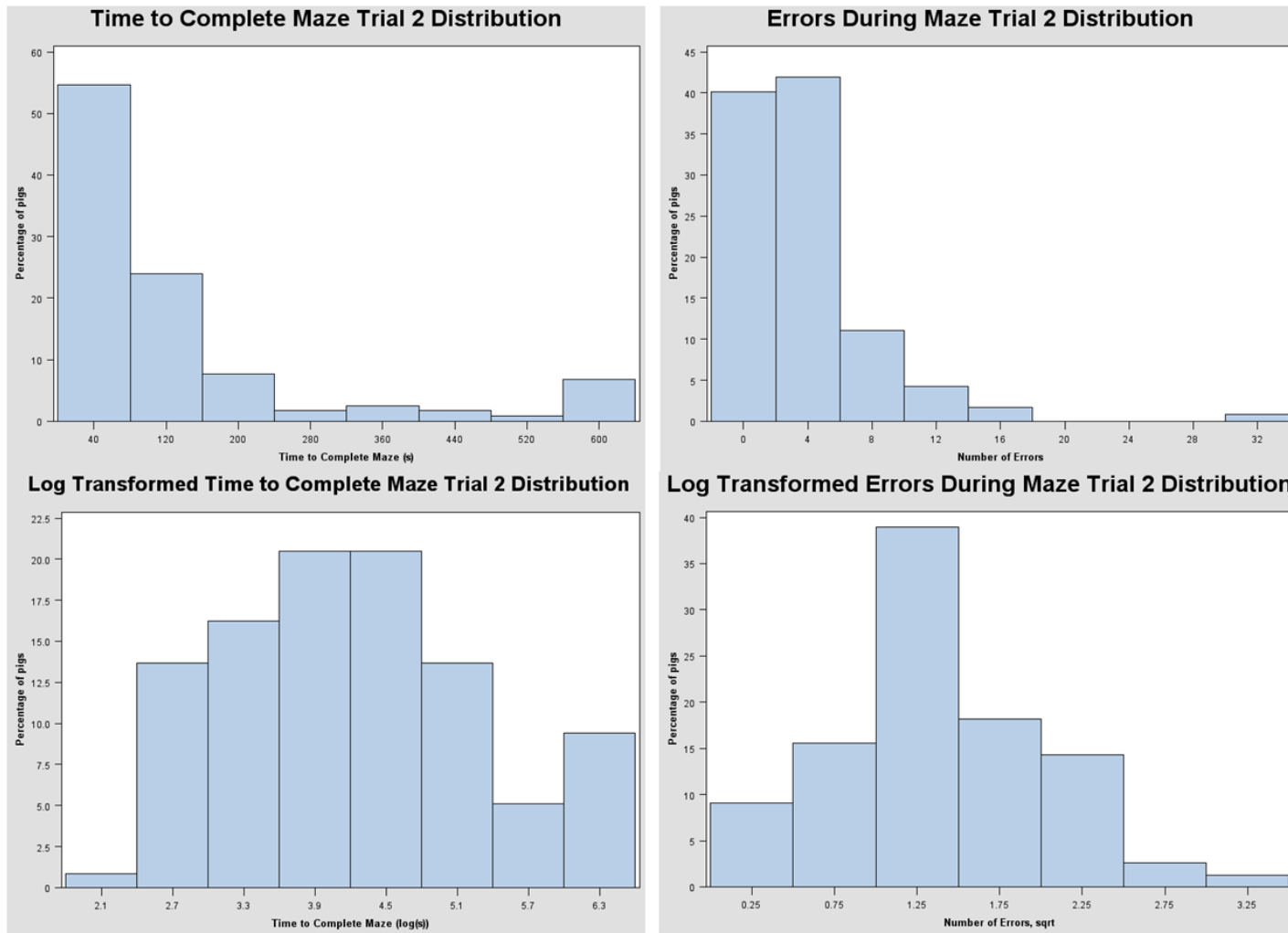


Figure A16. Maze Trial 2 Measurements Distributions

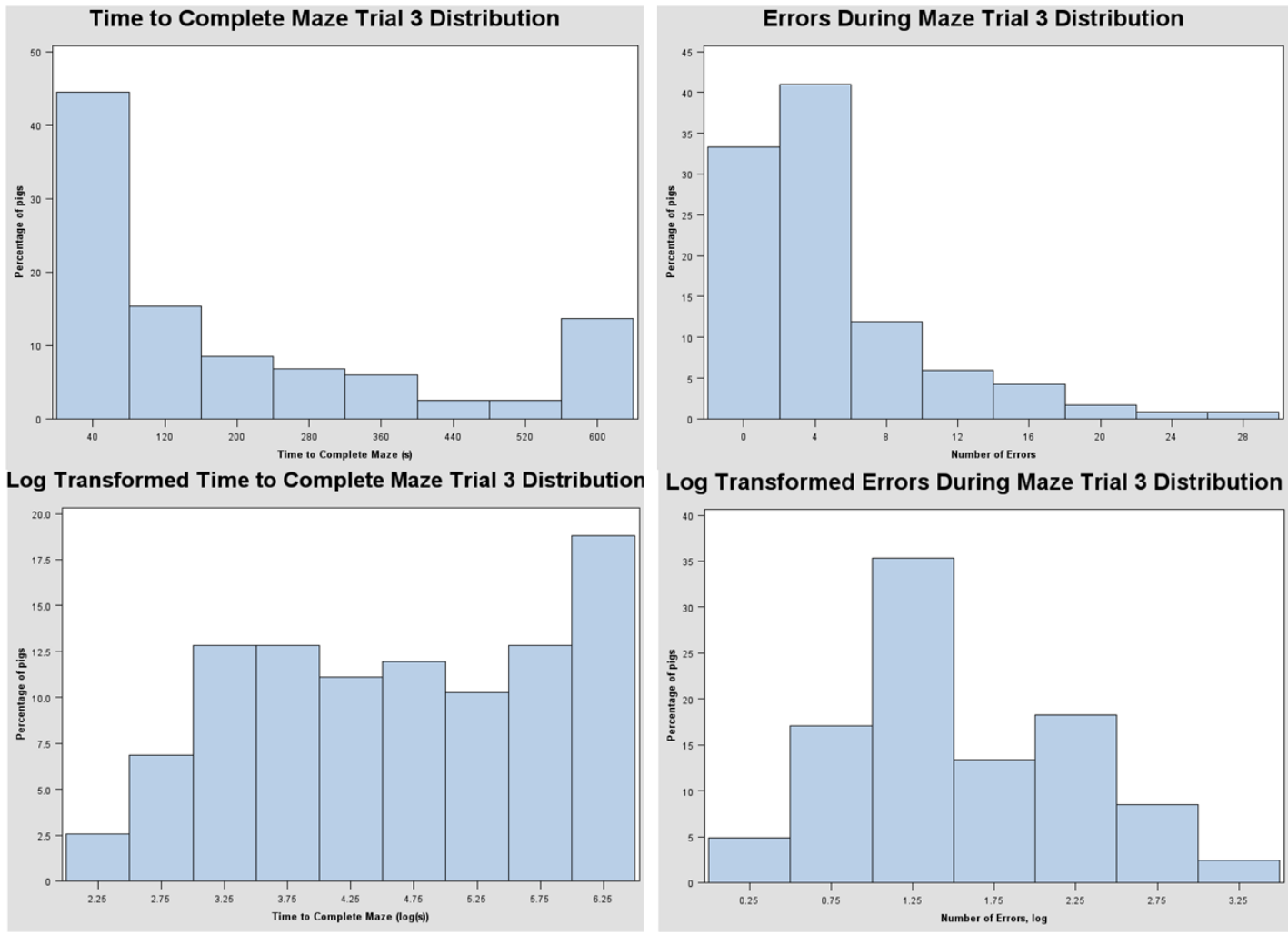


Figure A17. Maze Trial 3 Measurements Distributions

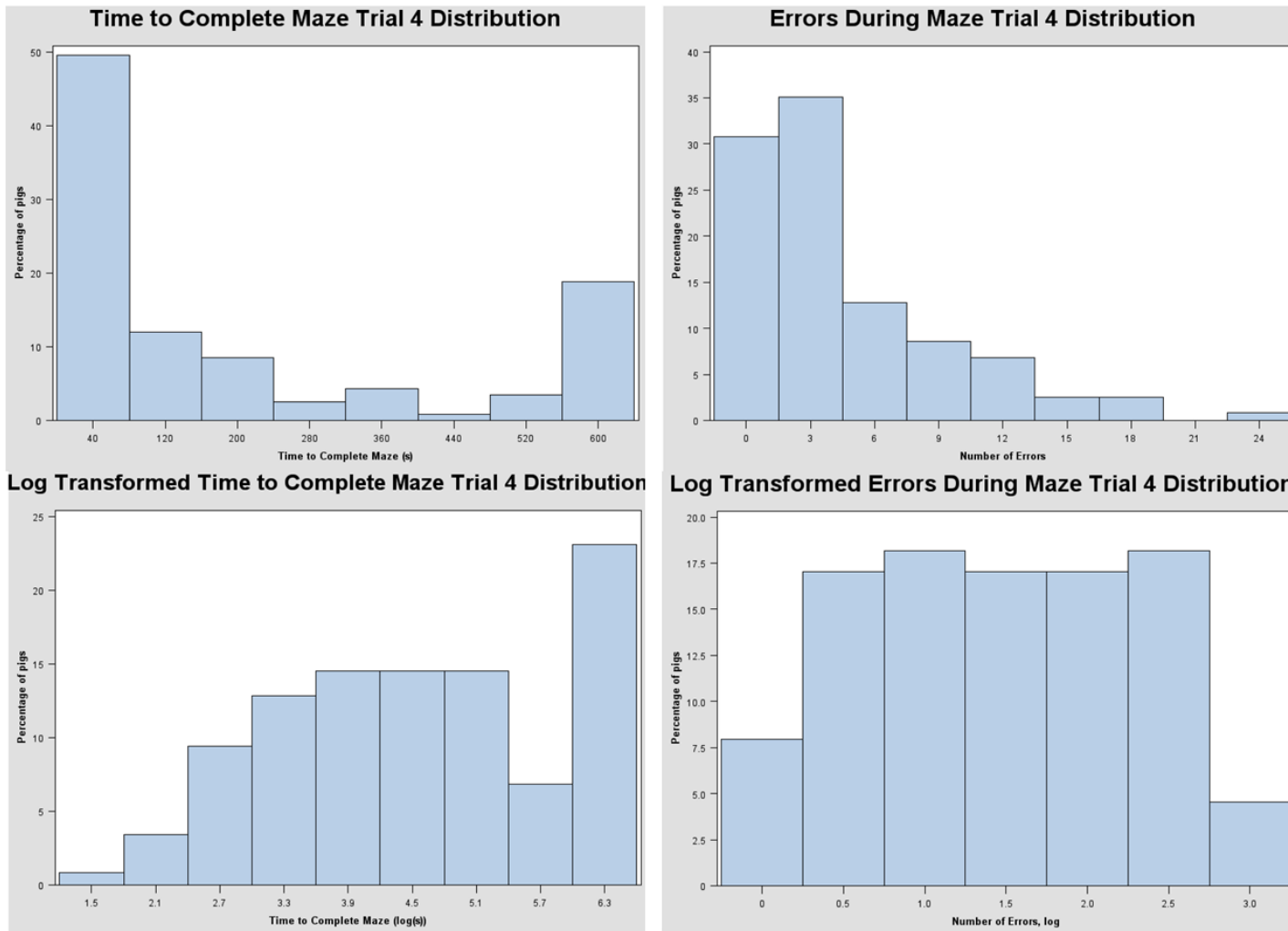


Figure A18. Maze Trial 4 Measurements Distributions

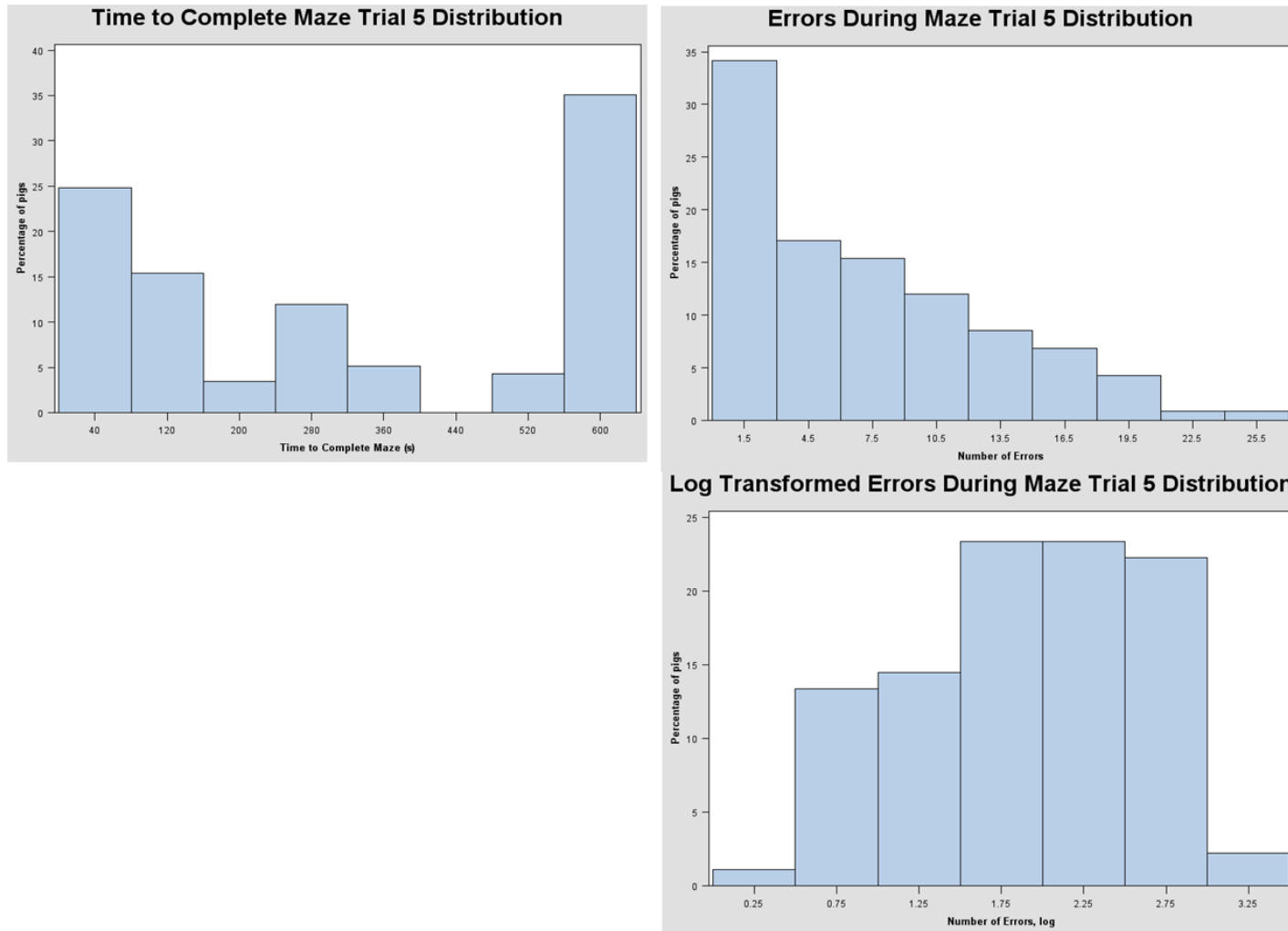


Figure A19. Maze Trial 5 Measurements Distributions

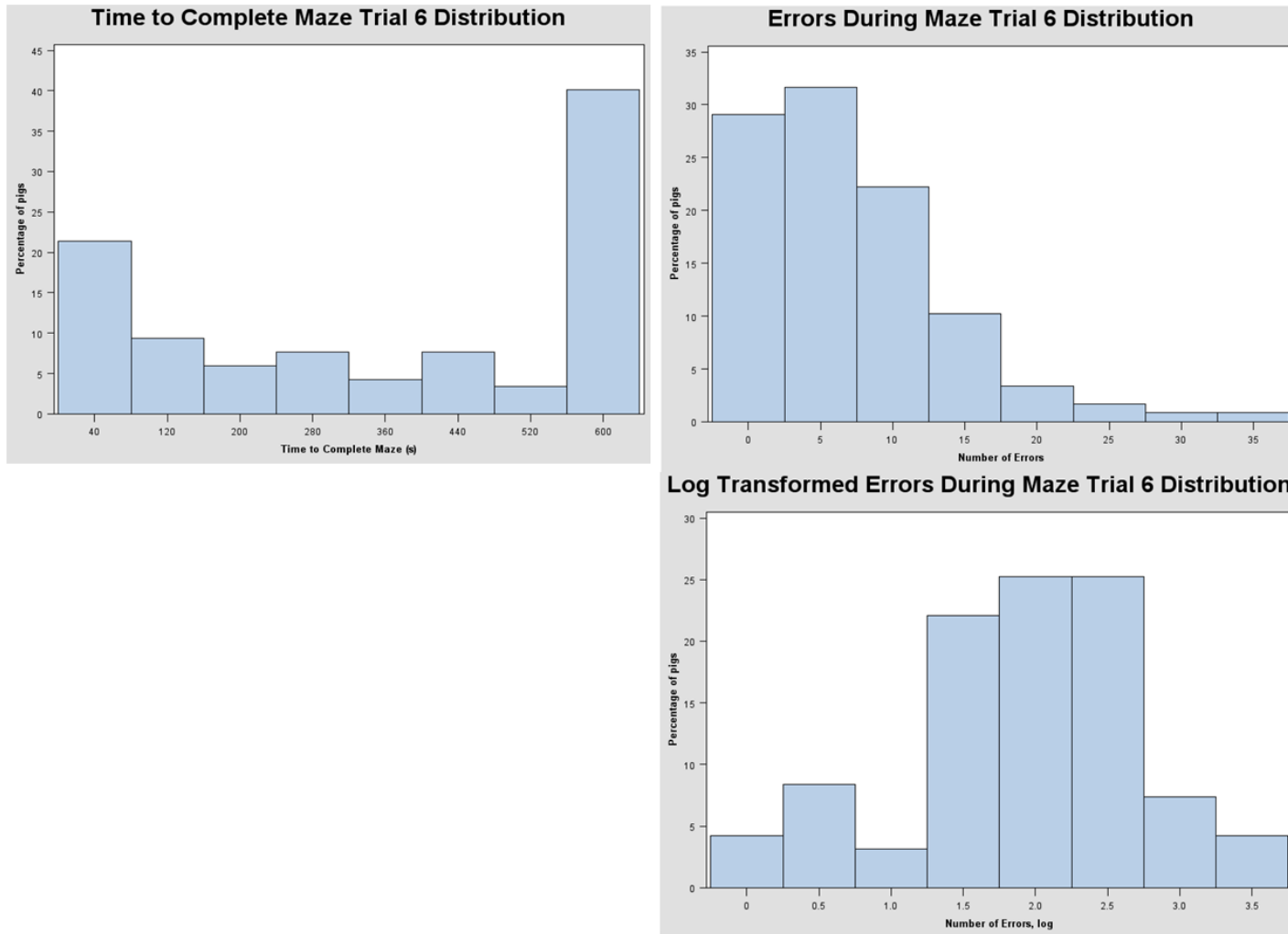


Figure A20. Maze Trial 6 Measurements Distributions

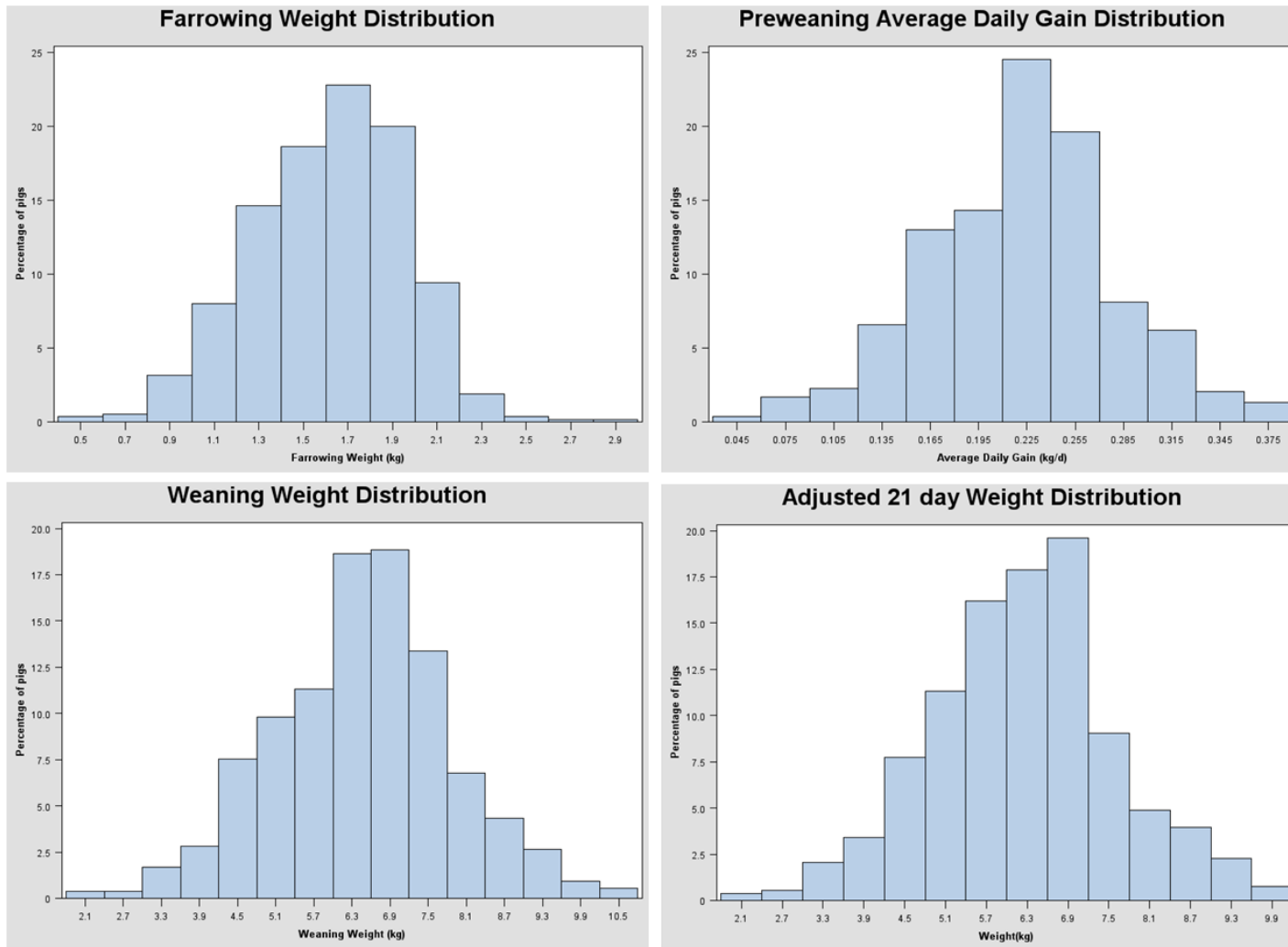


Figure A21. Production Trait Distributions